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TABLE OF CONTENTS

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Vol. 11 JANUARY, 1924 No. 1

THREE RECENT DECISIONS OF THE UNITED STATES SUPREME COURT, UPON VALUATION

By Leonard Metcalf[1]

Three decisions of great importance to those interested in the valuation of public utility properties were handed down by the Supreme Court of the United States in May and June of the present year. They are generally referred to as the Southwestern Bell, the Bluefield Water Works, and the Georgia Railway and Power Company cases:

No. 158—October Term, 1922, handed down May 21, 1923

The State of Missouri ex rel. Southwestern Bell Telephone Company, Plaintiff in Error, vs. Public Service Commission of Missouri and John A. Kurtz, Edwin J. Bean, Hugh McIndoe et al., etc.	In Error to the Supreme Court of the State of Missouri

Mr. Justice McReynolds delivered the opinion of the Court. Dissenting opinion by *Mr. Justice Brandeis*, with whom *Mr. Justice Holmes* concurred.

No. 256—October Term, 1922, handed down June 11, 1923

Bluefield Water Works and Improvement Company, Plaintiff in Error, vs. Public Service Commission of the State of West Virginia et al.	In Error to the Supreme Court of Appeals of West Virginia

Mr. Justice Butler delivered the opinion of the Court. *Mr. Justice Brandeis* concurred in the judgment of reversal, for the reasons stated by him in No. 158 supra.

[1] Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

No. 298—October Term, 1922, handed down June 11, 1923

Georgia Railway & Power Co. et. al., Appellants, vs. Railroad Commission of Georgia et al	Appeal from the District Court of the United States for the Northern District of Georgia.

Mr. Justice Brandeis delivered the opinion of the Court. Dissenting opinion by *Mr. Justice McKenna.*

SOUTHWESTERN BELL TELEPHONE COMPANY DECISION—NO. 158

"The Supreme Court of Missouri (-Mo.-) affirmed a judgment of the Cole County Circuit Court which sustained an order of the Public Service Commission of Missouri, effective December 1, 1919. That order undertook to reduce rates for exchange service and to abolish the installation and moving charges theretofore demanded by plaintiff in error. It is challenged as confiscatory and in conflict with the Fourteenth Amendment."

"During the period of Federal control—August 1, 1918, to August 1, 1919—the Postmaster General advanced the rates for telephone service and prescribed a schedule of charges for installing and moving instruments. The Act of Congress approved July 11, 1919 . . . . directed that the lines be returned to their owners at midnight July 31, 1919" and that the existing toll and exchange rates should continue in force for a period not to exceed four months after the taking effect of the act, unless sooner modified or changed by the public authorities.

On August 4 the Commission directed the Telephone Company to show why the rates fixed by the Postmaster General should be continued, and after a hearing made report and directed that the service rates be reduced and the charges for installation and moving be discontinued.

The Company produced voluminous evidence, including its books, to establish the value of its property dedicated to public use. The books showed an actual cost of $22,888,943. Its engineers estimated the reproduction cost new at $35,100,868, and its existing value after allowing for depreciation, $31,355,675.

"The only evidence offered in opposition to values claimed by the Company, were appraisals of its property at St. Louis, Caruthersville and Springfield, respectively, as of December 1913, February 1914, and September 1916, prepared by the Commission's engineers and accountants, together with statements showing actual cost of additions subsequent to those dates."

The Commission found a "total adjusted original cost, $20,456,-621.33" and tentatively adopted the sum of $20,400,000 as the value of the property for the purposes of this case.

In a concise and significant opinion the Supreme Court reversed the decision of the lower courts.

In commenting upon the action of the Commission the court said "Obviously the Commission undertook to value the property without according any weight to the greatly enhanced costs of material, labor, supplies, etc., over those prevailing in 1913, 1914 and 1916. As a matter of common knowledge, these increases were large. Competent witnesses estimated them as 45 to 50 per centum." The Court then quoted from its past decisions, as follows:

"In *Wilcox v. Consolidated Gas Co.*, 212 U. S. 19, 41, 52, this Court said

> There must be a fair return upon the reasonable value of the property at the time it is being used for the public . . . . And we concur with the court below in holding that the value of the property is to be determined as of the time when the inquiry is made regarding the rates. If the property, which legally enters into the consideration of the question of rates, has increased in value since it was acquired, the company is entitled to the benefit of such increase.

"In *The Minnesota Rate Cases*, 230 U. S. 352, 454, this was said

> The making of a just return for the use of the property involves the recognition of its fair value if it be more than its cost. The property is held in private ownership and it is that property, and not the original cost of it, of which the owner may not be deprived without due process of law.

"See also *Denver v. Denver Union Water Co.*, 246 U. S. 178, 191; *Newton v. Consolidated Gas Co. of New York*, 258 U. S. 165 (March 6, 1922); and *Galveston Electric Co. v. City of Galveston*, 258 U. S. 388 (April 10, 1922).

"It is impossible to ascertain what will amount to a fair return upon properties devoted to public service without giving consideration to the cost of labor, supplies, etc., at the time the investigation is made. An honest and intelligent forecast of probable future values made upon a view of all the relevant circumstances, is essential. If the highly important element of present costs is wholly disregarded such a forecast becomes impossible. Estimates for to-morrow cannot ignore prices of to-day."

"Witnesses for the Company asserted—and there was no substantial evidence to the contrary—that excluding cost of establishing the

business the property was worth at least 25 per cent more than the Commission's estimates, and we think the proof shows that for the purposes of the present case the valuation should be at least $25,000,000."

With reference to the return, the Court found that after making a 6 per cent allowance for depreciation, which was accepted by the Commission, the rates yielded "a possible 5½ per cent return upon the minimum value of the property, which is wholly inadequate considering the character of the investment and interest rates then prevailing."

The amount (4.5 per cent of gross revenue) paid annually, by the Company to the holding company, the American Telephone & Telegraph Company, as rents for instruments and for licenses and services, under the form of contract customary between the latter company and its subsidiaries, was also at issue, as it has been before a number of State Commissions. Of this annual charge 55 per cent was disallowed by the Commission. With reference to it the Court found "There is nothing to indicate bad faith. So far as appears, plaintiff-in-error's board of directors has exercised a proper discretion about this matter requiring business judgment. It must never be forgotten that while the State may regulate with a view to enforcing reasonable rates and charges, it is not the owner of the property of public utility companies and is not clothed with the general power of management incident to ownership."

Thus the Court stood firmly in its decision on the ground previously taken "that the value of the property is to be determined as of the time when the inquiry is made regarding the rates;" and ruled that the Commission gave no weight to the greatly enhanced postwar costs, though "Estimates for to-morrow cannot ignore prices of to-day."

Southwestern Bell Telephone—No. 158—Minority Opinion

With this important decision in the Southwestern Bell Telephone Company Case (No. 158) there was handed down also a minority opinion written by Mr. Justice Brandeis and concurred in by Mr. Justice Holmes. It is an exceedingly interesting argument for radical change in method of evaluating public utility property. It is valuable chiefly as indicating the personal viewpoint of these justices, and voicing, perhaps more effectively than has yet been done, the viewpoint of the advocates of the "prudent investment theory."

It is important to note, however, that the views were not those of the majority of the Court, and it may well be doubted if the results desired would follow the procedure advocated.

Mr. Justice Brandeis says "I concur in the judgment of reversal. But I do so on the ground that the order of the state commission prevents the utility from earning a fair return on the amount prudently invested in it. Thus, I differ fundamentally from my brethren concerning the rule to be applied in determining whether a prescribed rate is confiscatory. The Court, adhering to the so-called rule of Smyth v. Ames, and further defining it, declares that what is termed value must be ascertained by giving weight, among other things, to estimates of what it would cost to reproduce the property at the time of the rate hearing." Mr. Justice Brandeis, on the other hand, holds that "The so-called rule of Smyth v. Ames is . . . . legally and economically unsound." Believing that "It is consistent with the Federal Constitution for this (U. S. Supreme) Court now to lay down a rule which will establish such a rate base and such a measure of the rate of return deemed fair" he proceeds to develop his theory of prudent investment cost, in the hope of establishing a rate base "definite, stable and readily ascertainable."

Mr. Justice Brandeis' view is based also upon the fundamental conceptions that "The thing devoted by the investor to the public use is not specific property, tangible and intangible, but capital embarked in the enterprise;" and that "Upon the capital so invested the Federal constitution guarantees to the utility the opportunity to earn a fair return (Footnote: except that rates may, in no event be prohibitive, exorbitant, or unduly burdensome to the public)."

The latter views are at variance with the past positions taken by the U. S. Supreme Court, and it is certainly a fact that under commission control corporations have not been guaranteed, nor have they at all times earned, a fair return.

The difficulties and uncertainties and the abuses of present methods of valuation of public utility properties are forcefully presented. "The experience of the 25 years since that case (Smyth v. Ames) was decided, has demonstrated that the rule there enunciated is delusive. In the attempt to apply it insuperable obstacles have been encountered. It has failed to afford adequate protection either to capital or to the public. It leaves open the door to grave injustice." He shows the divergent results obtained by the application of the different bases of valuation referred to in Smyth v. Ames and the

great differences resulting from different interpretations of existing law. He analyzes the practice of the commissions,—with respect to principles governing the valuation of public utility properties,—and indicates their drift toward the prudent investment theory (he might have added, despite repeated reversals by the higher courts), and how "the tendency developed, to fix as reasonable, the rate which is not so low as to be confiscatory. Thus the rule which assumes that rates of utilities will ordinarily be higher than the minimum required by the constitution, has by the practice of the commissions eliminated the margin between a reasonable rate and a merely compensatory rate; and in the process of rate making, effective judicial review is very often rendered impossible. The result inherent in the rule itself is arbitrary action on the part of the rate regulatory body, for the rule not only fails to furnish any applicable standard of judgment, but directs consideration of so many elements, that almost any result may be justified."

The conditions under which the reproduction cost theory was developed are pointed out, and his view as to the danger to utilities of its future application, with the possibility of a long period of falling prices.

He holds that in essence there is no difference between the capital charge and operating expenses, depreciation and taxes. Each is a part of current cost of supplying the service, and each should be met from current income.

His confidence in the reform which he urges is great. "The adoption of the amount prudently invested, as the rate base, and the amount of the capital charge as a measure of the rate of return would give definiteness to these two factors involved in rate controversies which are now shifting and treacherous, and which render the proceedings peculiarly burdensome and largely futile. Such measures offer a basis for decision which is certain and stable. The rate base would be ascertained as a fact, not determined as matter of opinion. It would not fluctuate with the market price of labor, or materials, or money. It would not change with hard times or shifting populations. It would not be distorted by the fickle and varying judgments of appraisers, commissions, or courts. It would, when once made in respect to any utility, be fixed, for all time, subject only to increases to represent additions to plant, after allowance for the depreciation included in the annual operating charges. The wild uncertainties of the present method of fixing the rate base under the so-called rule

of Smyth v. Ames would be avoided; and likewise the fluctuations which introduce into the enterprise unnecessary elements of speculation, create useless expense, and impose upon the public a heavy, unnecessary burden."

Mr. Justice Brandeis holds that "What is now termed the prudent investment is, in essence, the same thing as that which the Court has always sought to protect in using the term present value." Many will differ with him in this view. He points out the difference between conditions twenty-five years ago when it was not possible to ascertain with accuracy what it cost in money to establish the utility, or what income had been earned or expended by it, and the present with the accounts of corporations kept according to the standards of and reviewed by public service commissions. He holds that the present situation makes possible the adoption of the prudent investment theory.

He touches upon the many meanings of the word "value" and states "the rule by which the utilities are seeking to measure the return is in essence reproduction cost of the utility, or prudent investment, whichever is the higher," as evidenced by the special report on valuation of public utilities, made by the American Society of Civil Engineers, October 28, 1916.

Mr. Justice Brandeis deserves credit for his clear and fearless expression of opinion. It reflects careful study and a desire to do constructive work, though many of the opinions expressed are directly opposed to those heretofore expressed by the court and followed in a long and fairly consistent line of decisions. It is to be remembered that the opinion was concurred in by but one other member of the Court,—Mr. Justice Holmes.

Mr. Justice Brandeis' view that prudent investment would furnish a better and fairer basis of valuation than the exercise of judgment based upon the results of applying various measures of value and the consideration of all relevant facts, will certainly be seriously challenged. That it may more readily be applied than the multiple standard of valuation dictated by Smyth v. Ames in many, if not most cases, may well be; that it is a workable standard under existing conditions is at least doubtful; that it will make possible the exercise of well-rounded judgment in determining value, and that it will reduce litigation or be more likely to lead to the determination of true value, is not likely.

Mr. Justice Brandeis has, however, done a real service in his clear expression of opinion, the discussion of which hereafter seems certain to clarify understanding.

BLUEFIELD WATER WORKS AND IMPROVEMENT COMPANY CASE—NO. 256

Mr. Justice Butler states "Plaintiff in error is a corporation furnishing water to the City of Bluefield, West Virginia, and its inhabitants. September 27, 1920, the Public Service Commission of the State . . . . made its order prescribing rates. . . . . The company instituted proceedings in the Supreme Court of Appeals to suspend and set aside the order. . . . . A final judgment was entered denying the company relief and dismissing its petition. The case is here on writ of error."

The Supreme Court denied the city's motion to dismiss the writ, on the ground that "there was not drawn in question the validity of a statute or an authority exercised under the State, on the ground of repugnancy to the Federal Constitution."

"The Commission fixed $460,000 as the amount on which the company is entitled to a return. . . . ." It held existing rates insufficient to the extent of $10,000, and authorized increase thereof.

The company claimed that the value of the property was greatly in excess of $460,000. There was submitted to the Commission evidence of value which it summarized substantially as follows:

a. Estimate by company's engineer on basis of reproduction new, less depreciation, at prewar prices.	$624,548.00
b. Estimate by company's engineer on basis of reproduction new, less depreciation, at 1920 prices.....	$1,194,663.00
c. Testimony of company's engineer fixing present fair value for rate making purposes................	$900,000.00
d. Estimate by commission's engineer on basis of reproduction new, less depreciation, at 1915 prices, plus additions since December 31, 1915 at actual cost, excluding Bluefield Valley Water Works, water rights and going value....................	$397,964.38
e. Report of commission's statistician showing investment cost less depreciation..................	$365,445.13
f. Commission's valuation, as fixed in Case No. 368 ($360,000) plus gross additions to capital since made ($92,520.53)...........................	$452,520.53

"It was shown that the prices prevailing in 1920 were nearly double those in 1915 and prewar time."

The Commission's analysis was discussed.

Mr. Justice Butler finds "The record clearly shows that the Commission in arriving at its final figure did not accord proper, if any, weight to the greatly enhanced costs of construction in 1920 over those prevailing about 1915, and before the war, as established by uncontradicted evidence, and the company's detailed estimated cost of reproduction new less depreciation at 1920 prices appears to have been wholly disregarded. This was erroneous. . . . . Plaintiff in error is entitled under the due process clause of the Fourteenth Amendment to the independent judgment of the court as to both law and facts. . . . ." "Rates which are not sufficient to yield a reasonable return on the value of the property used at the time it is being used to render the service are unjust, unreasonable and confiscatory, and their enforcement deprives the public utility company of its property in violation of the Fourteenth Amendment. This is so well settled by numerous decisions of this Court that citation of the cases is scarcely necessary." Reference is then made to Smyth v. Ames, 1898; Willcox v. Consolidated Gas Company, 1909; the Minneapolis Rate Cases, 1913; Southwestern Bell Telephone Company case, 1923.

"It is clear that the Court also failed to give proper consideration to the higher cost of construction in 1920 over that in 1915 and before the war, and failed to give weight to cost of reproduction less depreciation on the basis of 1920 prices, or to the testimony of the company's valuation engineer, based on present and past costs of construction, that the property in his opinion, was worth $900,000. The final figure, $460,000, was arrived at substantially on the basis of actual cost less depreciation plus ten per cent for going value and $10,000 for working capital. This resulted in a valuation considerably and materially less than would have been reached by a fair and just consideration of all the facts. The valuation cannot be sustained. Other objections to the valuation need not be considered."

With reference to the rate of return the Court says,—

"A public utility is entitled to such rates as will permit it to earn a return on the value of the property which it employs for the convenience of the public equal to that generally being made at the same time and in the same general part of the country on investments in other business undertakings which are attended by corresponding risks and

uncertainties; but it has no constitutional right to profits such as are realized or anticipated in highly profitable enterprises or speculative ventures. The return should be reasonably sufficient to assure confidence in the financial soundness of the utility and should be adequate, under efficient and economical management to maintain and support its credit and enable it to raise the money necessary for the proper discharge of its public duties. A rate of return may be reasonable at one time and become too high or too low by changes affecting opportunities for investment, the money market and business conditions generally."

It cited the following cases:

Willcox v. Consolidated Gas Company, 1909
Cedar Rapids Gas Co. v. Cedar Rapids, 1912
Des Moines Gas Co. v. Des Moines, 1915
Lincoln Gas Co. v. Lincoln, 1919
The Brush Electric Co. v. Galveston, 1921
City of Minneapolis v. Rand, 1923

and concluded "Under the facts and circumstances indicated by the record, we think that a rate of return of 6 per cent upon the value of the property is substantially too low to constitute just compensation for the use of the property employed to render the service."

The judgment of the Supreme Court of Appeals of West Virginia was reversed.

Mr. Justice Brandeis concurred in the judgment of reversal, for the reasons stated by him in the Southwestern Bell Telephone company case, to wit: "That the order of the state commission prevents the utility from earning a fair return on the amount prudently invested in it."

GEORGIA RAILWAY AND POWER COMPANY DECISION—NO. 298

Mr. Justice Brandeis delivered the opinion of the Court. It is important to note that this decision was rendered by the author of the minority opinion in the Southwestern Bell Telephone Company case and that it was handed down upon the same day, June 11, 1923, as that in the Bluefield Water Works and Improvement Company case discussed above.

"The gas supply of Atlanta is furnished by the Georgia Railway & Power Company. Authority to fix public utility rates is vested by law in the Railroad Commission. On September 20, 1921, the

Commission called upon the Georgia Company to show cause why the then maximum rate, $1.65 per 1000 cubic feet, should not be reduced; and hearings were duly had. The company insisted that under the proposed rate the net income would be less than 3 per cent on what it claimed to be the fair value of the property. The commission concluded that the net income under the proposed rate would be about 8 per cent on the value found by it. This difference in their views as to the percentage of probable return arose mainly from their difference as to the value of the property. The company claimed that it was at least $9,500,000. The Commission found that it was $5,250,000. On December 30, 1921, it ordered that the price of gas be reduced to $1.55.

"The Georgia Company and the Atlanta Gas Light Company, its lessor, then brought, in the federal court for the Northern District of Georgia, this suit to enjoin enforcement of the order, claiming that the rate prescribed is confiscatory. The case was heard upon application for an interlocutory injunction by three judges under Section 266 of the Judicial Code. The court did not approve in all respects the views expressed by the Commission; but it found that 'even were there considerable error in fixing values by the Commission, the rate would not appear to be clearly confiscatory' and that enforcement of the order ought not (to) be enjoined until the reduced rate had been tried. It, therefore, refused the interlocutory injunction; and the case is here on appeal under Section 238 of the Judicial Code."

The decision discusses the case under five captions.

"*First.* The objections mainly urged relate to the rate-base; and one of them is of fundamental importance. The companies assert that the rule to be applied in valuing the physical property of a utility is reproduction cost at the time of the enquiry less depreciation. The 1921 construction costs were about 70 per cent higher than those of 1914, and earlier dates when most of the plant was installed. So much of it as was in existence January 1, 1914, was valued at an amount which was substantially its actual cost or its reproduction cost as of that date. The companies claim that it should have been valued at its replacement cost in November, 1921—the time of the rate enquiry; and that the great increase in construction costs was ignored in determining the rate base."

Mr. Justice Brandeis asserts that "The case is unlike *Missouri ex rel. Southwestern Bell Telephone Co. v. Public Service Commission*, No. 158, decided May 21, 1923," although Mr. Justice McKenna

ridicules this view in his vigorous dissenting opinion. Mr. Justice Brandeis says, "Here the Commission gave careful consideration to the cost of reproduction; but it refused to adopt reproduction cost as the measure of value. It declared that the exercise of a reasonable judgment as to the present 'fair value' required some consideration of reproduction costs as well as of original costs, but that 'present fair value' is not synonymous with 'present replacement cost,' particularly under abnormal conditions."

The lower court gave careful consideration to replacement cost, but held that no rule "required . . . . 'slavish adherence to cost of reproduction less depreciation.' It discussed the fact that since 1914 large sums had been expended annually upon the plant; that part of this additional construction had been done at prices higher than those which prevailed at the time of the rate hearing; and it concluded that averaging results and remembering that values are . . . . matters of opinion . . . . no constitutional wrong clearly appears." The Supreme Court finds "The refusal of the Commission and of the lower court to hold that for rate making purposes, the physical properties of a utility must be valued at the replacement cost less depreciation was clearly correct," and quotes the Minnesota Rate Cases; Smyth v. Ames; and Willcox v. Consolidated Gas Company. Referring to the action of the lower court Mr. Justice Brandeis says "The opinion of the Court shows that it also made careful examination of the evidence submitted and that it recognized the applicable rules of law. While it differed from the Commission in some matters of detail, it sustained the latter's finding that the value was $5,200,000. The question on which this Court divided in the Southwestern Bell Telephone case, supra, is not involved here."

"*Second.* Two objections to the valuation relate to the exclusion of items from the rate base, namely: the franchise to do business in Atlanta, said to be worth $1,000,000, and so-called losses from operations during recent years, alleged to aggregate $1,000,000. These items were properly excluded. The franchise in question is not a monopoly. It is merely a perpetual permit, ... That past losses are not to be capitalized as property on which the fair return is based was held in Knoxville v. Knoxville Water Co. . . . ; Galveston Electric Co. v. Galveston. . . . . Here this conclusion seems even clearer than it was in those cases. The losses under consideration in the case at bar were obviously not a part of

development cost. They were due to insufficiency of previous rates."

"*Third.* Two further objections to the rate base relate to items of property included in it, which were alleged to have been undervalued . . . . working capital . . . . and going concern. . . . . We are not satisfied that either finding is erroneous."

"*Fourth.* The companies contend that there was error, also, in estimating the amount of the probable net income. One objection relates to the federal corporate income tax (10 per cent). . . . . The Commission treated the tax as a proper operating charge. The court disallowed it; and thus increased its estimate of probable net income. In this the court erred."

"The other objections relate to the amount of the depreciation charge. The companies say the rate should be 2.5 per cent. The Commission and the court allowed only 2 per cent. This question is one of fact, and we are not convinced that it was wrongly decided below."

"*Fifth.* The probable return based on the value and the probable income found by the Commission would be nearly 7.25 per cent. . . . . A return of 7.25 per cent—in addition to this tax exemption—cannot be deemed confiscatory. . . . . In making each of these changes the Commission fixed a rate which it estimated would permit the company to earn a return of about 8 per cent on the fair value of the property. Each change of rate was made upon careful consideration. If there was error, it was error in prophecy or error of judgment in passing upon the evidence. We cannot say that the evidence compelled a conviction that the rate would prove inadequate. . . . . Moreover, the decree is merely interlocutory."

The decision of the lower court was affirmed.

While the language of this decision appears to be in conflict with certain of the principles enunciated in the Southwestern Bell and the Bluefield Water Works decision, it is to be borne in mind that the same citations are made to earlier cases, and that this decision was handed down upon the same day as the Bluefield decision.

A more reasonable interpretation of the decision would seem to be that while the method of arriving at a result adopted by the Commission was not in accord with the principles heretofore laid down by the Supreme Court of the United States, the latter court recog-

nized the fact that the property bought before the war had been valued upon prewar price base, and the portions built during the war period, which were substantial in amount, were appraised at their cost, which was in part at least during a period of extremely high prices—higher than fair for valuation of the entire property,—and it was not satisfied that the figure thus reached was confiscatory and incompatible with an estimate based upon fair prices applied to the entire property.

On the other hand, that the wording of the decision at least, was ambiguous, is indicated by the forceful dissenting opinion of Mr. Justice McKenna, handed down upon the same day (June 11, 1923) as the decision.

Georgia Railway and Power Co.—Minority Opinion of Mr. Justice McKenna

He says "I am constrained to dissent on the authority of Missouri ex rel. Southwestern Bell Telephone Company v. Public Service Commission of Missouri, et al, decided May 21, 1923, and Bluefield Water Works and Improvement Company v. Public Service Commission of West Virginia, decided today.

"These two cases follow other cases which they cited, including that of Smyth v. Ames, decided a quarter of a century ago, declaring the rule of regulation to be, that in order to fix a rate for the use of property devoted to the public service, the property must be estimated 'at the time it is being used for the public.'" And again, "'that the value of the property is to be determined as of the time when the inquiry is made regarding rates.'"

"The Commission in the present case conceded the rule, and violated it, and upon a unique justification. It said 'The human race is only recovering from an experience the like of which the world never before endured—a world war—a world upheaval—an economic cataclysm. There are no stable measures of value to-day.' Upon this the Commission departed from the values which then prevailed, and from those that the rule of law prescribed, that is, the values prevailing at the time the property was being used for the public, and reverted to the values which obtained January 1, 1914,—values that had not existed for over seven years, and no prophecy could say when, if ever, they would exist again.

"To separate the Company from the conditions which existed at the time of regulation was arbitrary and condemned it, the Company,

to accept an inadequate return upon the value of its property, not only for the then time, but for an indefinite future time. Similar action was condemned in the Telephone case—no 'economic cataclysm' repelling. Similar action was condemned in the Bluefield case—no 'economic cataclysm' repelling.[2] May I ask what had become of the 'cataclysm?' Had it settled in Georgia in conscious indulgence to life and business in other parts of the country from its bewildering influence?

"The contrariety of decision cannot be reconciled. To anticipate a possible criticism, however, I should say a distinction is attempted to be made between this case and the Telephone case, a distinction, I think, not sustained by the record. It is said that the present case is unlike the Telephone case, in that 'here the Commission gave careful consideration to the cost of reproduction; but it refused to adopt reproduction cost as the measure of value.' The omission was the Commission's error—it was in disregard of the rule of the cases, disregard of the value of the utility at the time of its regulation—the time it was being used by the public. And such value was available. The problem was direct and simple—with no baffling element in it."

"The cost of the materials and of their fabrication was as much a measure of the value of the utility when reproduced as the cost of materials and their fabrication were a measure of the value of the utility when it was produced—a measure of value of reproduction and production."

"No attempt, however, is made to justify this case and the Bluefield case. It seems to be taken for granted that they can coexist in the books in harmonious association. Can they?"

"The Bluefield case decides . . . . that the Commission . . . . did not accord proper, if any, weight to the greatly enhanced costs of construction in 1920 over those prevailing about 1915 and before the war, as established by uncontradicted evidence . . . . this and the Bluefield case, are identical in errors. . . . . the Commissions did exactly the same thing, and yet the action of one is affirmed, and the action of the other reversed. This contrariety of decision I cannot reconcile. There should be reversal of both or the affirmance of both if their identities are to be observed.

[2] "The lower Federal Courts have not felt the bewildering effect—impotent effect I might say—that the Commission discovered in the post-war conditions. . . . . And a State Court has been equally free from confusion."

I, therefore, must dissent from one or the other of the cases, and as the Bluefield case has the support of the Telephone case, I dissent from the present case, there being a majority against it, and those cases, besides expressing my view of the law."

"It may be said that if I get rid of the Commission's action, I must take account of the District Court's judgment of it upon an independent consideration of the record. I realize that the challenge has serious strength, but as the Court's opinion is very long, I can only meet the challenge by what I consider the error of the opinion. The Court disregarded, as the Commission did, the rule of law that the value of the Company's utility should be at the time it was being regulated, that is, at the time it was being used. The Court, however, did not entirely agree with the Commission. It said 'in ascertaining the present values of physical properties, though correct rules were announced by the Commission, we do not think they were exactly followed.'"

FIRE PROTECTION REQUIREMENTS IN DISTRIBUTION SYSTEM DESIGN

By V. Bernard Siems[1] and D. Benton Biser[2]

The maximum discharge that may be required of a water distribution system is the quantity to be delivered for the purpose of fighting fires, and the proper provision for such a draught is the principle obligation of the distribution system design.

The quantity needed for fire protection, as compared to the total distribution capacity, is related in a general way to the population, the ratio decreasing as the population increases. A small town must devote a relatively greater proportion of its pipe line capacity to fire protection than a large city, and obviously, in the residential section of a city that proportion must be greater than in a commercial or industrial section. Likewise, the per cent of cost of the distribution system required for fire protection is inversely proportional to the population.

COST OF FIRE PROTECTION

This proportion, according to the judgment of Metcalf, Kuichling and Hawley (American Water Works Association Proceedings, 1911) is represented by the equation $Y = \frac{147}{X^{0.31}} - 12.1$ in which Y equals per cent of total cost, X equals population in thousands. By substitution in the equation this curve has been projected to a population equal to that of Baltimore (fig. 1). This is of comparative value only, however, as indicating the general trend and is unreliable when applied to the individual plant where there is any substantial deviation from normal conditions.

Although the per capita per day consumption for fire protection is too low to be considered in the total yearly consumption of a community, yet the value of this service to the community cannot

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be measured too highly in the saving in fire insurance premiums and in the economic loss resulting from fires. Although the quantity used for this purpose is small, when needed it must be delivered quickly and might tax the capacity of a system not designed to provide for this exigency.

STUDIES OF DISTRIBUTION SYSTEM PERFORMANCES

A distribution system, no matter how carefully designed to satisfy the requirements of a community, may in the course of time prove inadequate because, after all, it is an almost unalterable structure.

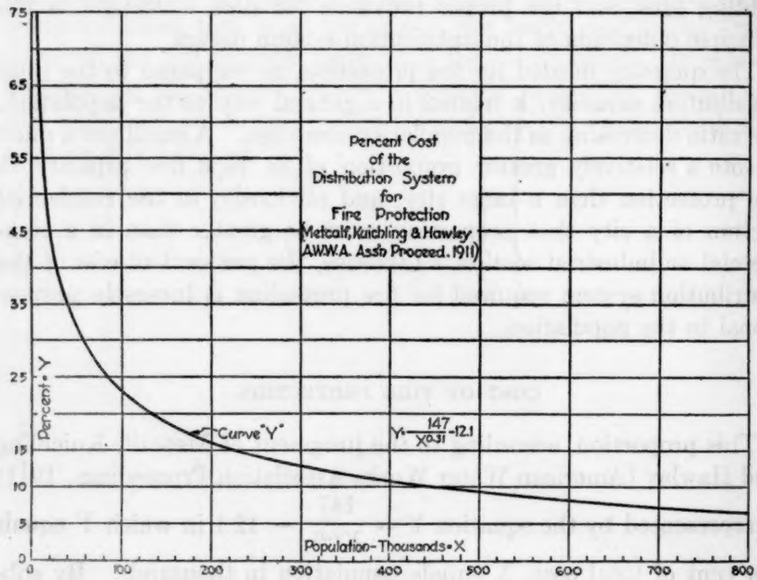

FIG. 1

The future needs for which it was constructed were assumed at the time, unless the development of the community for which it was designed was directed in an orderly manner by a systematic scheme of zoning. Let the character of the development change and the existing gridiron becomes inadequate, although this inadequacy may not be manifest, for the gridiron may yet be delivering sufficient water for consumption and the pressure may still remain unchanged by customary draughts upon the system. Casually, conditions are as good as at the time the system was designed, but the limit of

efficiency, beyond which the inadequacy of the system will become evident, may already have been reached.

In order to ascertain the true condition of an existing distribution system two studies are necessary—pressure surveys and investigations of the actual capacity of the system throughout its extent. An understanding of these properties not only indicates the manner by which the performance of the system might be improved, but also provides the fundamentals for new designs.

THE PRESSURE SURVEY

By the pressure survey there should be secured records of pressures during twenty-four hour periods. Information of any value in the study may be obtained only from such records, which show the maximum and minimum pressures during the period, the oscillation due to the nature of the supply source, and the possibility of water hammer in a gridiron that is insufficient to meet the required draughts, indicating the need for larger secondary mains or additional feeder main capacity; or, on the other hand, they may confirm the efficiency of the gridiron for its normal consumption draughts. By a comparison of the observed pressures with the theoretical pressures a fair idea of the consumption may be had. The record of the averages of the twenty-four-hour pressures may be made easily accessible by means of iso-baric lines upon a map of the town.

But a pressure survey is of value only as an indicator of conditions, for static pressures, even though they be theoretically ideal, may be misleading. A gridiron of small mains or even a large but long unsupported feeder main may consume in friction a high static pressure, and consequently any increase in pressure not brought about by larger mains, but principally only by extending the zone of a higher service to include sections of a lower service, or by increasing the static head in some such way, is not of lasting benefit, especially in a town whose consumption may be readily increasing.

FLOW TESTS ON FIRE HYDRANTS

Therefore, closely allied with the study of the pressures maintained in a water distribution system should be investigations of the actual capacity of the system throughout its extent. For such investigation as in the research that is being conducted in Baltimore for the improvement of the present system and the standardization of design,

use is made of a particular method which consists in making flow tests on fire hydrants. This is undoubtedly the most practical, economical, and instructive method of studying the efficiency of a distribution system.

The test is first carefully planned in the office. The boundary of the district to be investigated is determined. Due consideration is given to the normal consumption of the territory, the character of the feeder mains, the distance from the source of supply, the difference in elevation, age of pipes, etc., so as to calculate the size of an equivalent main from the source of supply to the point of test and the approximate quantity which theoretically should be discharged. In other words, the delivering capacity of the system at a focal point where the influence of the test upon the pressure in the system is to be observed is ascertained. The sizes of the water mains composing the gridiron are also considered and the number of fire hydrants to be used are selected.

With such preparations, the field operations are quickly, though accurately, made. Readings of the static pressure are taken at a central hydrant. The group of selected hydrants are then opened and, after the flow as indicated on the test gauge at the central hydrant has become stabilized, their individual discharges are measured simultaneously with a pitot tube attached to a calibrated gauge, which registers the velocity pressure of the issuing stream, care being taken to detect areas of no flow which may occur in weak streams or certain types of hydrants. During this operation the pressure at the central hydrant has dropped due to the heavy draught through the gridiron. Readings of this residual pressure are taken and the group of open hydrants closed. The registered velocity pressures converted into the corresponding quantities of water, correction being made for the type, size of outlet, the nature of the stream, etc., may then be compared with the theoretical quantities calculated.

Flow tests are of particular value for the various kinds of information they provide, which may be (*a*) the condition of the water mains with respect to obstructions such as closed valves, acute bends, etc. A study of the volume from each hydrant enables the engineer to locate the presence of such obstructions. (*b*) The discharge capacity of the existing mains and the efficiency of the gridiron. (*c*) The proper sizes of proposed mains. (*d*) The probable need of supporting mains or additional gridironing. (*e*) The reserve capacity of the system to meet such exigencies as serious fires, broken feeder

mains, etc. (*f*) The effect upon the gridiron of a definitely measured draught which serves as data from which may be calculated the effect of any consumption.

Flow tests on fire hydrants are necessary in studying fire protection probabilities, since the ability of the system to deliver the maximum quantity demanded by the test is comparable to the provision that should be made to meet the requirements of adequate fire protection.

FACTORS OF DISTRIBUTION EFFICIENCY

Pressure

The efficiency of the system for extinguishing fires depends upon the quantity of water that can be discharged at a certain pressure from fire hydrants a reasonable distance from the fire, which quantity is limited by the capacity of the source of supply, the static pressure, and the size and length of the water mains. Moreover, the efficient gridiron, besides delivering the necessary fire flow, should be capable at the same time of maintaining a residual pressure fairly sufficient for the needs of the ordinary consumption in the particular section supplied by it. This residual pressure, therefore, which is universally taken as 20 pounds is a fundamental consideration upon which the design of the gridiron must be based, and the size of the water mains to be used must be relative to the static pressures in the water distribution system.

Ordinarily, enough streams must be available with sufficient pressure to reach the roofs of buildings up to four stories in height and also to reach the seat of the fire through the flames, which is only possible with large and powerful streams. Small streams are easily vaporized by the heat of a large fire and hence are ineffective. Cities where fire engine pumps respond to each fire need not depend upon exceedingly high static pressures. With a properly proportioned distribution system and effective methods of fire fighting, hydrant pressures of 30 or 40 pounds are as good as those of 60 or 80 pounds. The additional pressure does not benefit the pumper, a fire engine being able to pump as long as there is pressure enough at the hydrant to deliver water to the pump. Very high pressures (100 to 200 pounds per square inch) tend to cause leaks and increase underground waste. It is far more important to have main capacity than to have high pressure.

However, a gridiron should not be dependent upon pumps to ensure a discharge sufficient for fire flows, but should have provided a static pressure great enough to produce effective fire streams unaided by pumps. Therefore, in a gridiron designed to deliver the proper quantity of water, 60 pounds pressure is desirable and should be the aim of the water works engineer to furnish in the distribution of water service.

Required fire flow

The next factor of distribution efficiency to be considered is that which limits the relation existing between the static pressure in the system and the size of the water main, that is, the probable fire flow required. This flow may be estimated for each type of development according to the method recently outlined by the National Board of Fire Underwriters, which developed as the result of cooperative studies conducted by J. H. Howland of the National Board of Fire Underwriters and the Baltimore City Water Department in the Highlandtown-Canton district of Baltimore. In this method the character of buildings, their undivided area, their height, combustibility, together with the fire department facilities are considered. A consideration of the factors which govern the adequacy of the water mains controls, therefore, any comprehensive study of a distribution system from a fire protection viewpoint.

Calculation of required fire flow

It was first believed that the required fire flows for a community were limited by its population and several formulae were developed. Shedd proposed an equation in which the number of fire streams, taken to be 250 gallons per minute each, was equated to $0.005\sqrt{\text{population}}$. Kuichling developed one in which the number of fire streams $= 2.8\sqrt{X}$, X being the number of thousands of population. The National Board of Fire Underwriters adopted a formula, which, in its finally revised form, became discharge in gallons per minute $= 1020\sqrt{X}(1-0.01\sqrt{X})$, X being population in thousands.

This formula modified somewhat by a consideration of structural conditions and features affecting the fire hazards is still quite universally used, but experimental data from the field confirm the growing belief that the flows required in a small town may not be relatively proportional to those in a large town; the entire population

of the small town might be engaged in one industrial enterprise and consequently the fire flow may be incomparable to that for the larger towns. Population should not be the single limiting factor. A new method of estimating required fire flows was evolved in which many variable factors were introduced and which was represented by the equation, $Q = (X+H)\ A + 1000 + (200E)$, for areas exceeding 2500 square feet, to be applied for fire areas up to 10,000 square feet, and $Q = (X+H)\ A + 5000 + (200E)$, for fire areas over 10,000 square feet. In these formulae A = area of undivided fire area of individual buildings or closely grouped buildings; H = factor depending on height and area of buildings, which for an area less than 10,000 square feet is

0.25 for 1-story
0.28 for 2-story
0.30 for 3-story
0.31 for 4-story
0.32 for 5-story
0.33 for 6-story and over

and for areas over 10,000 square feet H =

0.05 for 1-story
0.08 for 2-story
0.10 for 3-story
0.11 for 4-story
0.12 for 5-story
0.13 for 6-story and over

E = the number of engine or hose companies in excess of fire in service in the city, not to exceed fifteen in any case; X = the factor for combustibility of contents; 0.01 for low, 0.04 for average and 0.08 for high combustibility.

But an ideal equation should be applicable to all cases. This method, therefore, is undergoing a gradual revision and is not yet in its final stage, but is being critically applied to field conditions by the engineers of the National Board of Fire Underwriters. In this city much experimental work is being conducted by the Distribution Division of the Water Department to determine the value of the formula as an equation to be universally accepted.

It may be readily understood that the flow required to combat a fire depends in a great measure upon the height, fire area, and combustibility of a structure. The adjudgment of combustibility need not be hypercritical, for its varying degrees, as the case may

be, above or below an average, adds to or subtracts from the total quantity required.

The structural height of fire hazards may be limited in all considerations to six stories. Higher buildings are as a rule of modern fire proof construction and provided with house pumps; and moreover, a fire on the higher floors is reducible to or merely considered, for all purposes, as a fire in a structure of a height equivalent to the number of floors involved. This is brought out in figure 2, where it is seen that the increasing height tends to decrease the quantities, and that proportionally the greatest quantities are needed below the third story.

The most important factor is the fire area, that is, the area undivided by a fire wall, through which a fire may spread unhampered. Thus the brick walls dividing a continuous row of buildings do not constitute fire walls unless they are continued above the roofs by so-called parapet walls, for, without this, a fire, though obstructed within the building, would be unhindered from spreading under the roof to adjacent buildings.

The three factors noted above are not sufficient of themselves to determine the required flow. The experience of the National Board of Fire Underwriters indicates that there are other items to be introduced, one of which is the maximum fire engine pump capacity considered—which in any case should not exceed 10,000 gallons per minute, the equivalent of 40 good fire streams or thirteen 750 gallon-per-minute fire pumps. One-third of the difference between the maximum fire pump capacity considered for a fire area of any size, and the average fire engine pump capacity provided must be added to the fire flow required as determined by the height, fire area, and combustibility factors. This difference between the maximum and average fire pump capacities represents the approximate quantity of water that is required to provide for the quantity lost through wastage in hose couplings, broken hose, pump slippage, main and hydrant obstructions, etc. It is evident that the entire quantity of water used at a fire does not fall upon it.

Research to determine a correction factor ("Baltimore equation")

Aside from this modification it has been our contention that this allowance for the extra quantity of water needed at a fire, which is so closely related to the number of fire streams and hence directly related to the fire area considered, should be further defined. The

need for a more complete definition of the factor, upon which we have been working, has also been expressed by the National Board of Fire Underwriters, who have been applying their formula to field conditions. It is our belief that, although the fire area proper should remain that enclosed by fire walls, yet adjacent buildings, if there are any, are exposed and not a small quantity of water must be provided to protect these exposed areas.

Applications of the formula emphasize the importance of this exposure factor, which is a variable defining the fire area. Unless this definition is made, an isolated structure, surrounded by its grounds or bounded by wide streets, permitting of easy access and distribution of fire fighting forces, would require, according to the present formula for determining fire flow, the same quantity of water for protection as a structure of the same height and area adjoined by other hazards in a congested section.

It is reasonable to assume that this quantity would be negligible for very small fires, but would increase greatly as the extent and seriousness of the fire increases. In reality the records of past fires and the judgment and experience of the Chief of the Fire Department, City of Baltimore, indicate that this quantity increases as the square of the probable required flow. The compilation of all the available data on the excess quantity necessary to protect structures menaced by fires in an adjacent building produces a parabolic curve the equation for which is found to be: excess quantity in gallons per minute, representing this exposure factor, equals the square of the probable fire flow, in gallons per minute, as calculated by the National Board of Fire Underwriters' method, divided by 50,000 or symbolically expressed $X = \frac{Y^2}{50000}$.

This correction need not be applied to the quantity calculated for fire areas exposing other buildings from one side only, but is only to be added when the exposure to fire is on two or more sides and substracted whenever there is no exposure. It has been our endeavor to revise the formula of the National Board of Fire Underwriters to conform to all conditions and to develop a method for determining quantities for fire protection applicable to great and small structures in large and small towns alike.

Application of revised equation for fire flows

Diagrams 1, 2, 3 and 4 in figures 2, 3 and 4 illustrate the successive steps in calculating therequired fire flow.

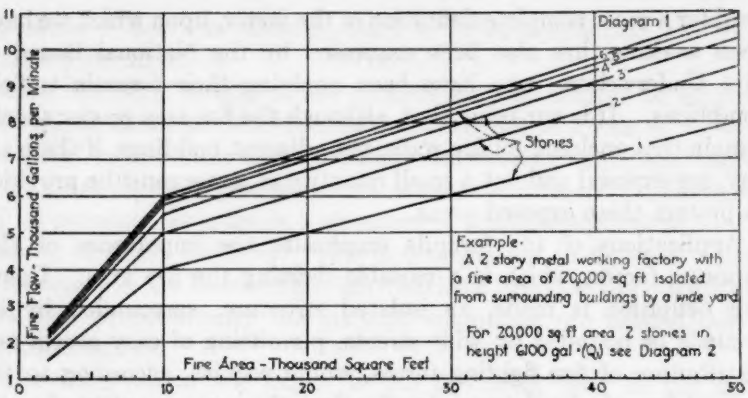

Fig. 2. The National Board of Fire Underwriters Tentative Diagrams Showing the Fire Flows Required for Fire Areas of Varying Heights (Q_1)

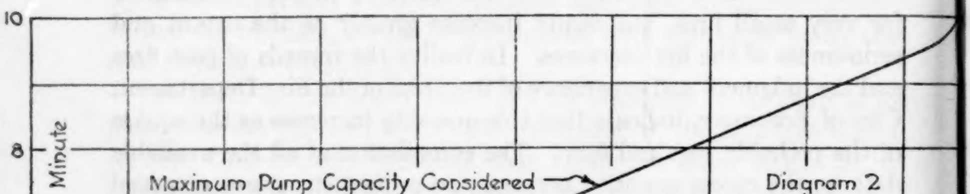

Fig. 3. The National Board of Fire Underwriters Tentative Diagrams Showing Fire Engine Pump Capacity (Q_2) and Combustibility (Q_3)

Diagram 1, figure 2 represents a judgment, based upon studies conducted in the Highlandtown-Canton District mentioned above,

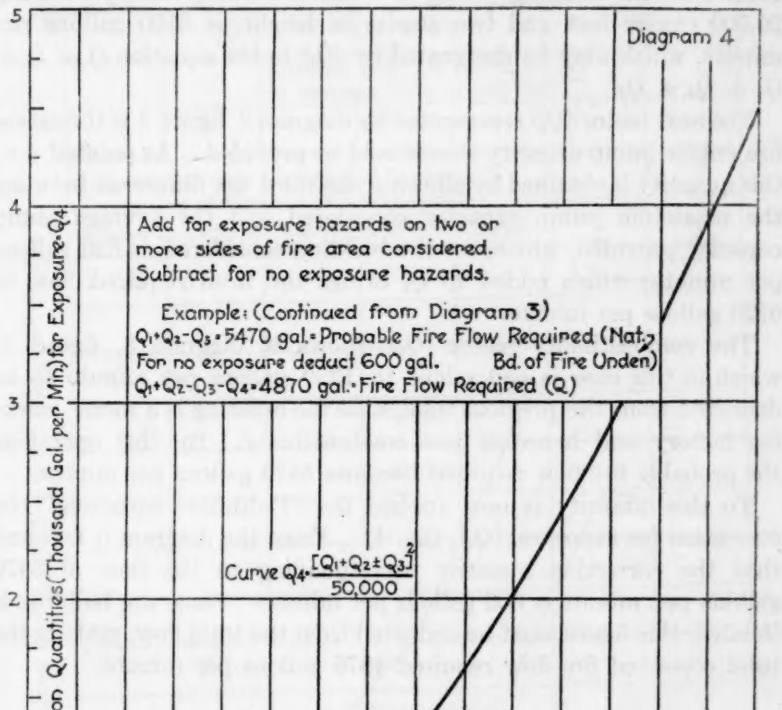

FIG. 4. EXPOSURE FACTOR (Q_4) FOR CORRECTION OF PROBABLE REQUIRED FIRE FLOW, "BALTIMORE EQUATION"

of the fire flow required for buildings or groups of buildings so situated as to constitute essentially one fire area, of heights from one

to six stories. For the better understanding of the application of the diagrams an example is given. The indicated quantity on diagram 1 for the building, which is a metal working factory covering 20,000 square feet and two stories in height, is 6100 gallons per minute, which may be designated by (Q_1) in the equation $Q = Q_1 + Q_2 \pm Q_3 \pm Q_4$.

The next factor (Q_2) represented by diagram 2, figure 3 is the excess fire engine pump capacity that should be provided. As pointed out, this quantity is obtained by allowing one-third the difference between the maximum pump capacity considered and the average pump capacity provided, which, for the building considered, is 620 gallons per minute; which added to Q_1 brings the total required flow to 6720 gallons per minute.

The combustibility factor (Q_3), shown in diagram 3, figure 3, which in this case is equivalent to 1250 gallons per minute to be deducted from the previous total, since the building is a metal working factory and hence of low combustibility. By this operation the probable fire flow required becomes 5470 gallons per minute.

To this quantity is now applied the "Baltimore equation," the correction for exposure, (Q_4), (fig. 4). From the diagram it is found that the correction quantity corresponding to the flow of 5470 gallons per minute is 600 gallons per minute. Since the building is isolated, this figure must be deducted from the total flow, making the total corrected fire flow required 4870 gallons per minute.

ELEMENTS OF DESIGN

Estimation of fire flows based upon future development of a community

In estimating the probable required fire flows in this city, we consider the future development of each section according to the regulations outlined by the Zoning Commission, and from analysis of the actual trend by field inspections. Such practice should be universal. In order to design a water distribution system intelligently, the character of the future development of the community and the location and widths of proposed traffic arteries must be known. Many times in communities where a system of city planning was not followed, small mains have been laid into new territories on the theory that the demand would be slight, only to be replaced by larger mains when the territory became more closely built or its character changed. Where a system of city planning is followed,

the future consumption in a newly developed territory may be anticipated and although the gridiron and even the supporting

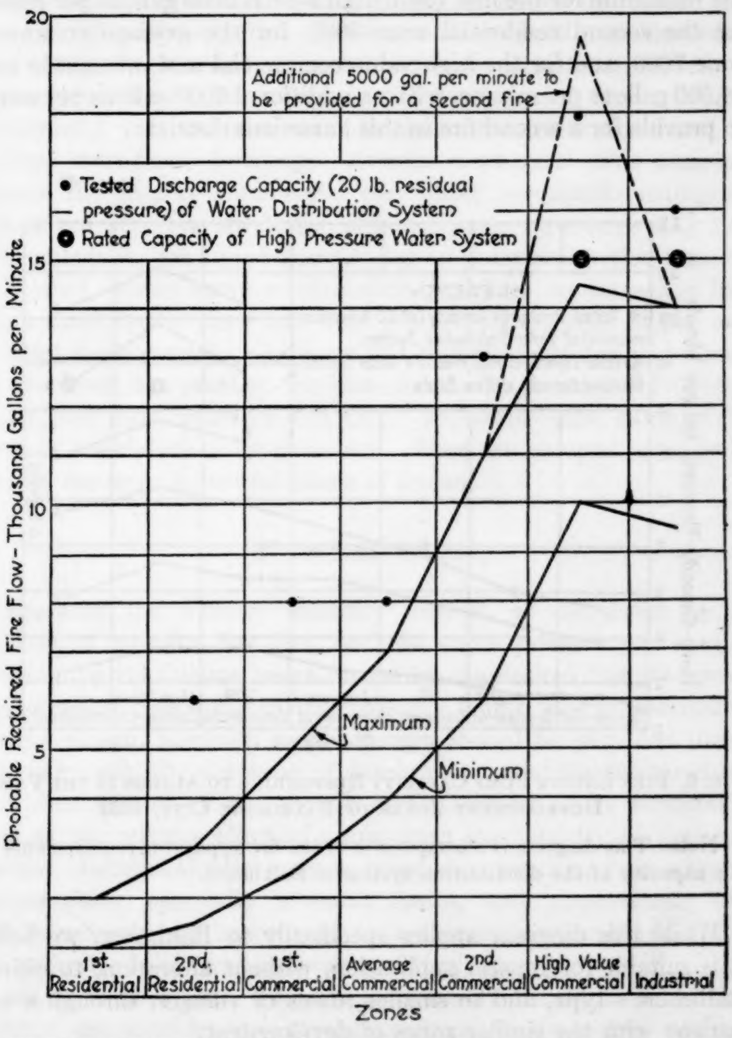

FIG. 5. PROBABLE FIRE FLOWS REQUIRED FOR SERIOUS FIRES IN THE VARIOUS DEVELOPMENT ZONES OF BALTIMORE CITY, 1923

system of lateral feeder mains may not be complete for some time, yet a determination of the size of the feeder main extension to be economically installed may be made in advance.

Figure 5 shows the probable limits of the fire flows required in the various development zones in a city like Baltimore. It is seen that the maximum for the first residential zone is 2000 gallons per minute, for the second residential zone 3000, for the average commercial zone 7000, and for the high value commercial and mercantile zones 14,500 gallons per minute, with an additional 5000 gallons per minute to provide for a second fire in this hazardous district.

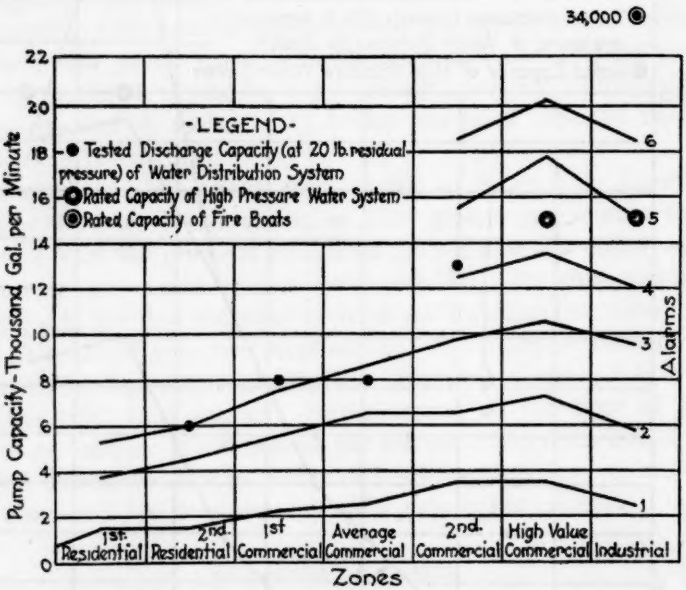

FIG. 6. FIRE ENGINE PUMP CAPACITY RESPONDING TO ALARMS IN THE VARIOUS DEVELOPMENT ZONES OF BALTIMORE CITY, 1923

Note: This diagram is a comparison of the fire apparatus requirements and the capacity of the distribution system in Baltimore.

While this diagram applies specifically to Baltimore, we believe it is suitable for general application, without alteration, to cities of Baltimore's type, and to smaller towns or villages, through a comparison with the similar zones of development.

To facilitate the comparison of structural conditions in a small town with those indicated on the diagram, the designated zones may be defined as follows: *First residential*—a purely residential development without stores, the dwellings being individual and surrounded by yards. There are no large apartment houses in this zone. *Second*

residential—this development is more congested. Dwellings may be in block construction with occasional community stores. Structures in this zone are not generally separated by yards. *First commercial*—although this development is partly residential in character, the number of small stores is greatly increased. It represents a transitional stage in the development of a residential community to one commercial in character. Here are found the typical store-front dwellings. *Average commercial*—this zone embraces the smaller commercial and minor mercantile enterprises. There are very few dwellings, although some structures may have apartments on the upper floors. *Second commercial*—this zone is a congested, purely commercial section, buildings are large and high. *High value commercial*—this zone represents the limit of the commercial development. Here are the largest structures to be found in the town, the greatest fire hazards, the most congested development, the most valuable property. *Industrial*—the name of this zone is descriptive of its character. Here are grouped more or less closely the large industrial plants of a town.

Water main capacity

Knowing the delivery capacity desired, as calculated by the method of required fire flow, and the static pressure provided, by considering the friction losses caused by the desired flow, the proper size of water mains and their permissible length may be ascertained. In the design, however, ample margin should be provided for the future growth, the character of development, and the increased consumption caused by the growth of the district to be supplied, as well as the relative effect of aging upon the capacity of the water mains. Incidentally the increase in velocity, resulting from a greater consumption, especially in small mains, may approximate their critical velocity and hence cause that main to have reached the limit of its serviceability while yet comparatively new.

Mains smaller than 6 inches in diameter should never be considered, except under very special conditions, in designing a gridiron. A very short length of 4-inch pipe is inadequate for delivering two good fire streams of 500 gallons per minute and even then the friction loss caused by such a discharge would necessitate a very high static pressure, and the velocity produced in the pipe by the discharge would be four times the critical velocity for a pipe of that size.

Source of supply

Another important factor of the efficiency of the system is the capacity of the source of supply which should provide at least for a maximum fire draught of ten hours duration at a sustained pressure during the peak period of domestic consumption and during the dry season.

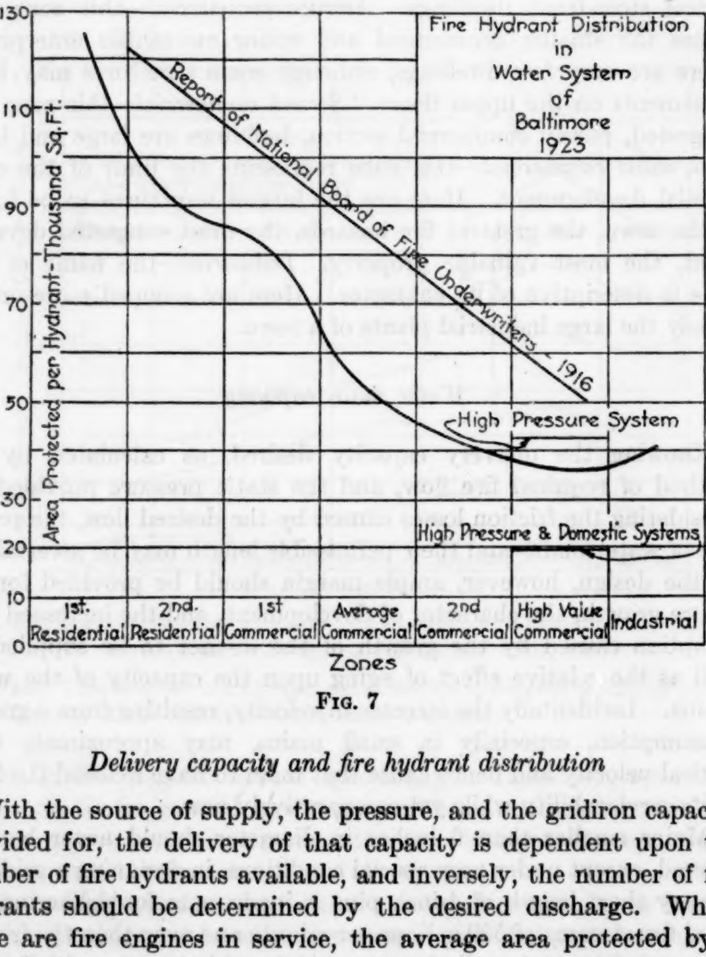

FIG. 7

Delivery capacity and fire hydrant distribution

With the source of supply, the pressure, and the gridiron capacity provided for, the delivery of that capacity is dependent upon the number of fire hydrants available, and inversely, the number of fire hydrants should be determined by the desired discharge. Where there are fire engines in service, the average area protected by a single hydrant, which depends upon the number of fire streams made necessary by the requirements of fire protection for that district, may be somewhat greater than where no engines are available; and as the

required fire flow is increased the area per hydrant should be decreased.

The area of a city block, providing the streets are not uncommonly narrow, constitutes the natural fire area unit and affects the spacing of fire hydrants. The probable required fire flow for a block that is congested and consists of two and three story brick dwellings in block construction interspersed with stores would be about 4000 or 5000 gallons per minute. According to the schedule of the National Board of Fire Underwriters, this flow would necessitate a hydrant distribution sufficient to limit the protected area per hydrant to 85,000 or 90,000 square feet or one to two hydrants for each city block. A less congested block of dwellings, in which there are no large apartment houses, a development as might be found in the outlying districts of the residential parts of a city, would require a fire flow of not more than 2000 gallons per minute and a corresponding average area per hydrant of 110,000 or 120,000 square feet or one hydrant for each city block. It is not our practice to include highways, whose width exceeds 80 feet, in determining the hydrant distribution, as such a width serves as a barrier against the spread of fire, and to include it in the area protected by the hydrant seems unjust.

On gridirons of secondary mains, hydrants should be placed only at highway intersections in order to ensure accessibility to them and a well supported flow from the converging mains in the cross highways.

Fire hydrants should be systematically allocated, with the following precepts in mind:

1. They should be equidistant from each other.

2. They should be placed at the same relative corner of the highway intersection to make for uniformity and to facilitate their discovery by the fire department; in order to provide for this, there should be either parallel mains, one on each side of the street, or the single main should be centrally placed; as the hydrant branch should always be as short as possible to reduce friction losses, this uniformity of distribution would otherwise be impossible.

3. There should be at least one hydrant within the boundaries of each city block in order to provide in as many cases as possible against the necessity of crossing car tracks with hose lines.

Two schemes for the systematic distribution of fire hydrants are illustrated in figure 8.

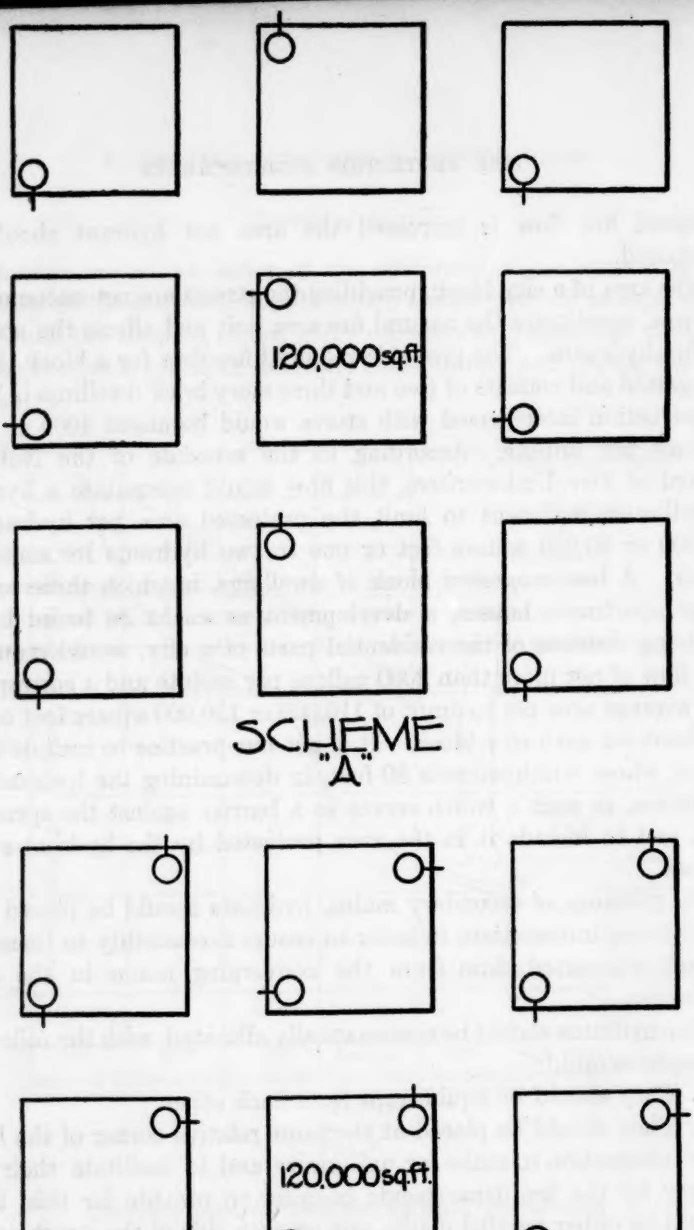

Fig. 8. Schemes for a Systematic Distribution of Fire Hydrants

Scheme "A" is the proposed distribution for one hydrant per city block of 120,000 square feet. It will be seen that there is a hydrant at each street intersection, there are two hydrants available on each face of the block, whereas hydrant distribution requires only one per 120,000 square feet, yet by this arrangement four hydrants are in reality available within a radius of about 200 feet about each block.

Scheme "B" is that for two hydrants per city block, or a distribution equivalent to one hydrant per 60,000 square feet. By this arrangement two hydrants are placed at each intersection, making four hydrants available on each face of the block, and eight hydrants available within a radius of about 200 feet about the block.

Designing for fire protection

In the determination of the capacity for which the gridiron is to be designed, the domestic consumption may be neglected in residential sections, the fire flow being taken as the total discharge through the pipe. Indeed the same principle is indicated in the commercial and industrial sections, as it has been found that the required fire flow greatly exceeds the consumption demand. Yet the consumption in such developments, is considerable, and as there is usually a certain period during the day when it reaches a peak far above the average draught, some allowance for the domestic consumption in the determination of the necessary pipe capacities of the supply mains seems to be necessary. Investigations are now in progress in Baltimore to determine, if possible, a relationship between the pipe capacities made necessary only by the required fire flows and those for the fire flows combined with the domestic draught.

In the determination of the pipe size for a new system, analytical methods are employed. The available static pressure, the required discharge and the hydrant distribution made necessary by this discharge are known. The size of the supply mains to the new territory may be judged by the quantity to be furnished and a permissible loss in head, considering the available static pressure, to the edge of territory. The summation of the friction loss in the feeder mains outside the section, the hydrants and hydrant branches, the number of which is determined by the required fire flow, and the allowance of 20 pounds residual pressure in the system, deducted from the static head, gives the total remaining head available for friction loss in the gridirion, upon which to base the size of the secondary mains.

In the calculations a fair allowance for aging, tuberculation, etc., of the pipes may be made by taking $C = 100$ in the Hazen and Williams' tables.

For example: assume two principal highways extending from a town, separated by a distance of 3000 feet, and from both of which a residential development is gradually expanding to eventually form a completely built-up area between them. Let it be assumed that the development has reached a point about 700 feet, or about two blocks, from the highway, and that it is desired to extend a water main to this point. Let the nature of the development be such that, with a hydrant distribution as recommended, a discharge of 500 gallons per minute is required from each hydrant. Let the loss in the hydrant and hydrant branch, flowing 500 gallons per minute, be 4 pounds, and the loss in the outside system up to the point from which the new main will be taken, be 4 pounds. The sum of these losses, added to the residual pressure of 20 pounds, which is the desired pressure to be maintained in the system during the discharge, is 28 pounds. Let the difference in elevation between the point considered and the source of supply be such that the theoretical static pressure is 35 pounds. Then this pressure, less the 28 pounds above, leaves 7 pounds, which is applicable for friction losses in the new water main. By reference to the Hazen and Williams' tables, it is found that 500 gallons per minute is available with this loss through 770 feet of 6-inch main.

But provision must also be made for the future development. Assume that the development has passed the point considered above and, in this process, has become more congested and requires a greater quantity of water for adequate fire protection. If the 6-inch main were extended to join the supply main in the other avenue, 3000 feet distant (which in this case it is assumed is in every way equal to the supply main first mentioned), so that the new main would receive equal supplies from both ends, then by the same method of calculation, it is found that where the 500 gallons per minute was before available, there is now an available discharge of 783 gallons per minute. At the weakest point in the design, midway between the two avenues, there is available a discharge of 704 gallons per minute. Therefore, it may be assumed that with these conditions a 6-inch main will not only provide for the present, but, as the first step in a progressive gridiron design, will be ample for future requirements.

Fire protection requirements in European design

There does not seem to be much importance given to fire protection in European distribution system design. One German authority allows 4 or 5 liters per second for fire protection in addition to the quantity estimated for the domestic consumption. Hydrant branches are installed at distances of 50 to 120 meters, although hydrants are first installed only on the alternate branches. The sizes of the mains are determined from the estimated per capita consumption per linear meter of improved highway, and mains as small as 100 millimeters in diameter are permitted in the design.

CONCLUSIONS

Fire protection is a paramount obligation upon a water works. To ignore this obligation is calamitous. By the flow test we may judge the ability of a water system to furnish the territory it supplies with adequate fire protection. By applying the principles upon which such tests are based we may be guided in designing new water distribution systems. To ensure an economical and permanent design, anticipation of the development of the territory to be supplied should be made possible through the adoption of a definite scheme of community zoning. A revised method of determining required fire flows has been developed which should be applicable to all conditions. From our investigations, it seems that the required fire flow is the criterion upon which the pipe capacity of any gridiron system should be based.

FINANCING MUNICIPAL WATER SUPPLY EXTENSIONS[1]

By Caleb Mills Saville[2]

The purpose of this paper is to present a logical and practical method of financing municipal water main extensions. The several methods in more or less common use will be discussed, and their advantages and drawbacks commented upon, particular attention being given to the so-called "guarantee" and "assessment" methods. By means of example and reference to practical conditions, an attempt will be made to prove that the assessment method is, on the whole, the most equitable one for municipal use. Methods in use will be discussed, and citations from public utility commissions, together with some legal opinions, will be given. An outline will be given of the principles of the assessment method as employed at Hartford, Conn., and the results of its workings will be considered.

How to finance main water pipe extensions into new territory must be one of the oldest problems of water supply service and the perfect solution seems not yet to have been found. Tied up with it are an almost infinite number of conditions, some of local character and others of general application.

In the older states where the first public water supply systems had their beginnings it is easy to imagine the causes that led to the custom, which now is very prevalent, of requiring the applicant for a new extension of the system to give assurance to the utility that the cost of the work for his personal benefit would not become a charge on the other takers. Hence the basis of the so-called "guarantee" method had its origin, under which the petitioner or person desiring the extension guarantees a certain return on the cost in water rates or otherwise.

With reservations this method is applicable to both privately and publicly owned water systems. There are, however, many inequalities inherent in its administration from the standpoint of the consumers as a whole, from that of the petitioner, and from that of the utility, which are a cause of complaint.

[1] Presented before the Detroit Convention, May 24, 1923.

[2] Manager and Chief Engineer, Water Department, Hartford, Conn.

In looking through a tabulation in a recent magazine[3] it was found that of 656 municipalities, reporting on methods of financing water pipe extensions, 167 or 25.4 per cent depended on "bond issues," 34 or 5.2 per cent "by assessment," and the remaining 455 or 69.4 per cent used "surplus" or "appropriation" and similar means.

These are rather loose terms when critically studied, and meanings quite diverse can be assigned them by different persons who are not familiar with the individual case. It is probable that the majority of the places included in the list mentioned above require some guarantee of adequate income on the investment.

Whether the "bond issue" is redeemed by water department earnings or from the general tax levy is unknown. If from the former it is questionable practice; if by the latter it is poor accounting and may be unsound finance.

As a rule, however, municipal water department officials have little to do with methods of financing the department activities, and equally as well the majority of the members of city governments have little or no knowledge of fiscal relations.

In the case of those departments reporting "surplus" or "income" as the source of the funds used by them to finance their extensions, if these funds are applied to construction for the general improvement of the system they may be considered as being taken from the depreciation reserve, which might be an allowable procedure. If, on the other hand, they are used to pay for extensions into new territory for local benefit only, the application is improper, because it is taxing the whole number of rate payers for the advantage of a few.

Any method of paying for main pipe extensions into new territory is basically wrong which places the whole or any part of the cost of the extension on the consumers as a whole.

As to the method of financing capital expenditures out of return from water rates, in the case of water works operated by a municipality, the Montana Public Service Commission said (Kavanaugh vs. Town of Whitefish, P. U. R., October 26, 1922, E, p. 208):

> To ask for rates which not only pay operating expenses, depreciation, taxes, in the case of a private plant, and perhaps sacrifice taxes in the case of a municipal plant, but in addition a sum for capital accounts, violates every principle of rate making which is grounded on the theory and usually the fact that the consumers, as a class, are not the furnishers of capital.

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[3] American City, pamphlet No. 215.

Also (P. U. R., 1915 B, 331. L. C. 169, Cal. 318, 146 Pac. 640):

The *expense* of making water extensions demanded of a water company by inhabitants of a municipality is not the controlling feature in determining the reasonableness of the demand therefor, because water rates as a whole must be sufficient to allow a fair, just and reasonable income on the property of the company devoted to public use, which would include such necessary expenditures; but an additional expenditure by the company, as an additional burden on the rate payers as a whole, should not be imposed for the benefit of a particular portion of the community where a reasonable necessity for it exists.

What is a fair and reasonable income on the property devoted to the public use? The most common rate of return allowed by public utility commission appears to be 8 per cent, although in some cases 6 per cent has been used. Considering the peculiar characteristics of water utility bonds, the last named rate seems altogether too low, when it is considered that these securities are most often locally owned and are not commonly listed in market reports. In the Hackensack Water Company Case, (Board of Public Utility Commissioners, N. J., April 28, 1917) the Commission said that "a return of 7 per cent on the base with a reasonable allowance for depreciation and operating expenses" was acceptable. In establishing the gross annual income, in addition to the fair return of 7 per cent, the Commission allowed as the annual depreciation and operating expense an amount equivalent to about 3.8 per cent of the total capital. These allowances ordinarily total about 12 per cent for a private company paying cash dividends to stockholders, while a municipally operated plant should be able to conduct its business for about one-half this return, depending on the state of its works and whether or not it has consumption and income proportional to plant value.

As to the method by which the cost of extensions is financed by "appropriations," meaning, it is presumed, from the tax levy, there is little or no sound excuse, unless it is that the payment is made in lieu of taxes and fire-protection service furnished to the city without other charge.

Even in such a case, public utility decisions are against such scrambling of accounts, and generally unite in holding that a water department, even if owned by the municipality, should receive cash for what it supplies to the city and in return should pay cash for what the city supplies to it.

Any appropriation from the tax levy that is not applied for the general welfare of the community is discriminatory and neither legal nor just. In view of the above, this method of financing extensions for development purposes is considered to be without adequate basis in fact, and therefore will not be given further consideration.

In the sense used above the word extension is taken to mean the installation of a water pipe of size sufficient to provide proper domestic and fire protection service for the immediate locality, with the water department assuming all cost in excess of the above which is necessitated for the good of the service.

The two methods which seem to qualify under the above condition are those designated as "guarantee" and "assessment," with their variants.

The guarantee method is proper if the payment in rates or otherwise received from the extension is sufficiently large to cover not only the proper portion of all maintenance and operating charges of the water department service, but also to pay interest and depreciation on the extension.

It is not proper if the guarantee is so small that either water is given away or the burden of the investment is carried by the consumers as a whole.

In some municipal instances the water rates would never meet the conditions named as proper, but the administration goes serenely on, and when the income of the department becomes too small to meet expenses rates are raised because of every reason but that which indicates poor bookkeeping and improper financial management.

In the opinion of the author the best and surest remedy for this condition is governmental regulation of municipally owned utilities as well as of those under private operation.

Through this means a uniform system of accounting is set up and the department not only properly segregates its own accounts and at the end of the period knows just where it stands financially, but it is able also to compare its costs with those of similar systems, which is an excellent incentive for getting the best work out of those on whom the responsibility for efficient and economical results rests.

As a general rule municipal utility works will seldom of their own initiative establish proper systems of accounting and the loose

methods of public finance are all too plainly apparent, but if a uniform method is prescribed by the state all must comply therewith, and the results are quickly in evidence.

In an article in "Public Works," July 6, 1918, p. 9, Mr. J. W. Ledoux stated his opinion, backed by certain mathematical deductions of a practical nature, that "under ordinary circumstances it does not pay to lay a water works distributing pipe extension in privately operated works unless the annual revenue obtainable thereon is considerably over 25 per cent of the cost."

There is, of course, no definite relation tying together the cost of supplying water, income from water rates, and the cost of laying main water pipes.

A municipally operated plant is supposed to supply water at cost, and by cost is meant the actual cost of operation, including interest, sinking fund payments and depreciation, plus a nominal margin sufficient to meet ordinary annual changes in cost of labor and materials, beside the variations in income that occur from year to year.

The depreciation fund cannot be called on to meet ordinary extension costs, because it is needed for replacements and capital expenditures for the good of the service as a whole. There is thus no surplus from income from which to finance the cost of ordinary extensions into new territory.

Under the method by means of which a certain percentage of the cost is guaranteed per year in water rents or otherwise, if the works are run at cost, other consumers pay either for the extension which benefits solely a limited locality, or else they pay for the water used in that locality. In either case this is discrimination and not allowable under the rules of equity.

If persisted in, this method would lead to bankruptcy, except that in a municipally run corporation there always may be recourse to increase in rates or to the tax levy to meet the deficiency.

As a matter of fact, what usually happens is that depreciation funds are conspicuous by their absence and when water rates are established they are made sufficiently large to discount the future. The margin thus created is a bank on which to draw until increased costs of running the department begin to approach the limit of income.

From the above it appears that the so-called "guarantee method" of financing main pipe extensions is not properly applicable to municipally operated plants.

On the other hand, the guarantee method is proper for privately run works because here there must be a good margin of profit in order to attract capital and continue in business. A portion of this profit, if so desired by the stockholders, may properly be invested in extensions which will yield still more profit.

So much for theory, but even municipally operated plants should be run at some margin of profit, and new money must be found for improvements in the ordinary course.

In the long run no business corporation, whether publicly or privately operated, can be run on a margin barely sufficient to meet operating and fixed charges. Unless earnings are sufficiently over the amount required to pay expenses, eventually there will be a breakdown.

At the meeting of this Association in New Orleans in 1910 the matter of financing water main extensions was quite fully discussed by Messrs. J. W. Ledoux, Miles J. Spaulding, and others. (P. 193 et sep., Proceedings 30th Annual Convention), and an article in "Public Works," July 6, 1918, by Mr. Ledoux, on this subject, contains many valuable suggestions.

Mr. Spaulding, as far as the writer knows, was the first member of the Association to call attention to some of the injustices of the present methods of financing main pipe extensions and to suggest that all ordinary distribution mains should be paid for by the frontage owners and not from the water fund.

In considering the guarantee method the basic proposition is:

The extension should pay cost of supplying water, including fixed and operating charges on the original plant investment.

It is sometimes contended that, if there is plenty of water and the works, including supply lines, are adequate, all that is necessary is for the extension to pay operating costs, i.e., such costs as are a function of the amount of water used. This is discriminatory because it puts the burden on the other consumers of carrying fixed charges on the original plant and the extension draws a benefit without payment.

This method fails to take into consideration the fact that for every foot of extension of distribution system added to the plant there must sometime or other be a corresponding extension of the producing plant, the proportionate cost of which, under this method, the extension does not bear.

There is a difference to be recognized between sale of *surplus* water at a low rate and the *supply* of water to regular consumers. In the former case any income obtained over and above operating cost is a gain without obligation to the consumers as a whole, while in the latter case there is an obligation with no gain.

It is also contended that, if there is plenty of water and the works at present are adequate, all that is necessary is for the extension to pay a proper proportion of fixed charges on the original plant together with operating expenses. This also is discriminating, because it has laid the burden of the cost of extension made for local benefit on the consumers as a whole.

As to development, it is almost impossible to make so much as a moderately accurate estimate of the time which it will take for even a legitimate development to reach completion. From a rather hasty study of Hartford conditions, however, it appears that, with a bona fide intention for development in a moderately good locality, it may be reasonable to assume 50 per cent of full maturity in from two to five years and practically complete occupancy of the lots in five to ten years. What comparison without relationship there is between original cost of main pipe extentions, interest and amortization charges, water rates per consumer and income per front foot is readily found from figure 1. This diagram also clearly shows the fallacy of guarantee in water rates or otherwise as far as it affects a municipal plant operating at cost.

With a privately operated utility it seems proper to use the guarantee method, as the profit in the water rates should be sufficient to finance the extension after full development of the locality.

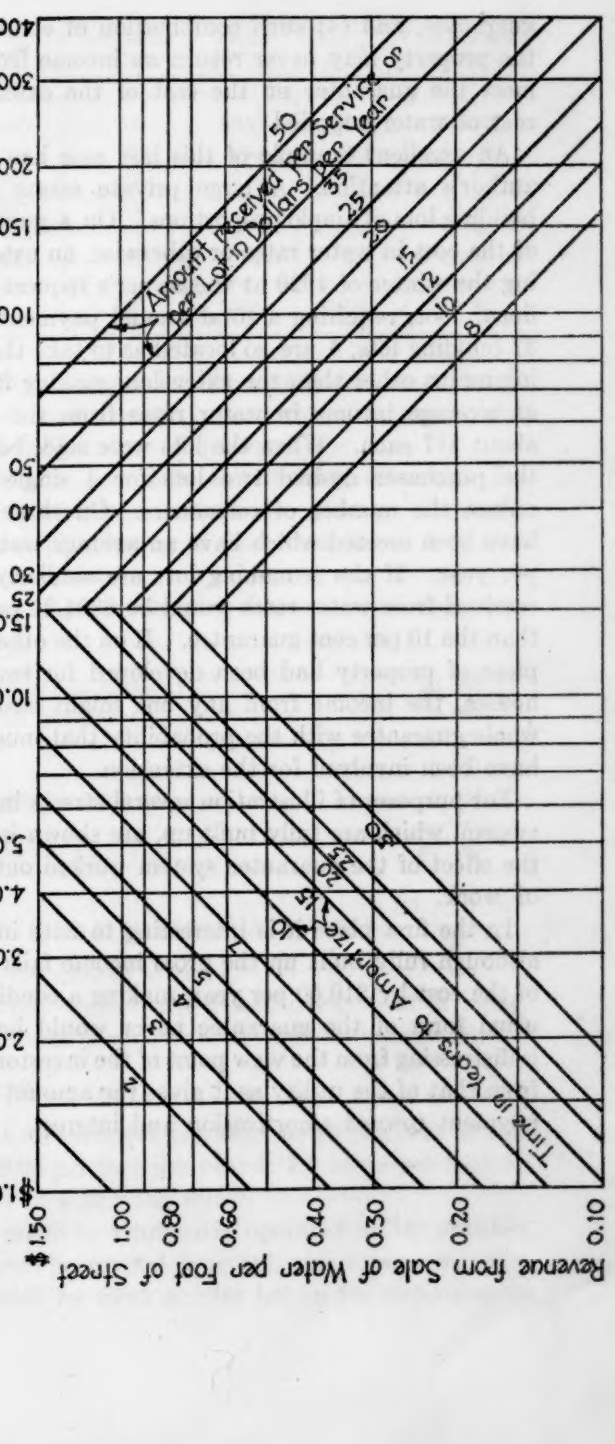
With a publicly operated utility run substantially at cost, there appears to be no argument for the use of this method unless it be for an amount in addition to water rates and sufficient to pay interest and amortize principal in a given term of years. This solution logically leads to the assessment method of financing water main extensions to be discussed later.

Some other objections to the guarantee method for use in municipally operated plants are (1) the difficulty in getting all abutters in a street to be participants in the guarantee; (2) the increased return in property valuation to all abutters on the extension at the expense of those who are uniting to undertake the burden; (3) the fact that through over-enthusiasm as to development it may be many years before a return is available sufficient to extinguish the

DIAGRAM SHOWING RELATION BETWEEN

(1) Revenue from sale of water per foot of street. (Average lot frontages and average amount received per year per service (or lot) varying.)

(2) Time required to amortize cost per foot of pipe line construction. (Amount of annual payment per foot of street and original cost of pipe line varying). It is assumed that 4½% annual interest is paid on pipe line cost and that balance of annual payment is placed in sinking fund at 4% interest compounded annually.



guarantee, and (4) such combination of conditions may arise that the property may never return an income from water sufficient to meet the guarantee on the cost of the extension, even excluding cost of water supplied.

An excellent example of this last case has recently come to the author's attention. A large private estate was cut up into 32 building lots of ample proportions. On a guarantee of 10 per cent of the cost in water rates or otherwise, an extension was made during the winter of 1920 at the owner's request which cost $3.00 per linear foot, requiring a total annual payment of $476.10. Of the 32 building lots, 4 are so located as to take their supply from existing mains other than the extension, making it necessary to receive an average income in water rates from the 28 remaining lots of about $17 each. When the lots were sold, however in many cases the purchaser desired two lots for a single house, which would reduce the number of consumers. On three of these lots houses have been erected which have an average water payment of $28.16 per year. If the remaining lots are similarly developed the total received from water rates would be $394.24 per year, or $81.86 less than the 10 per cent guarantee. If on the other hand this particular piece of property had been developed for several large apartment houses, the income from any one might easily have covered the whole guarantee with the probability that much less expense would have been involved for the extension.

For purposes of illustration several streets in the Hartford, Conn., system, which are fully built up, are shown in the table below and the effect of the guarantee system worked out on the basis of cost of work.

In the first place it is interesting to note in this tabulation that although fully built up the gross income fails to reach 10 per cent of the cost by $10.60 per year, making a condition which under the usual form of the guarantee never would be extinguished. This is distressing from the view point of the investor, but is advantageous from that of the utility as it gives the amount of the difference as a payment toward amortization and interest.

STREET	LENGTH	DATE	NUMBER OF CONSUMERS	WATER INCOME	COST	INCOME PER CONSUMER
	feet					
1	695	1910	16	$206	$694	$12.90
2	653	1914	20	230	981	11.50
3	1167	1921	22	220	3464	10.00
4	562	1921	11	89	1680	8.10
5	653	1921	14	121	1950	8.60
6	335	1920	8	99	987	12.40
	4065		91	$965	$9756	$10.80

If this were a privately operated utility entitled to earn a fair return on the capital invested—say 7 per cent—the guaranteed income should be much larger than 10 per cent.

Based on the above pipe line data and making allowance for street intersections, 85 feet is a reasonable average frontage, with an average cost for pipe laying of $2.40 per linear foot and assuming water supplied at *cost.*

Applied to linear foot of pipe extension for municipal operation (at cost):

Interest and amortization (see figure 1)	$0.167
Cost of water = income (see figure 1)	0.254
Total expense	0.421
Water income—street wholly built up	0.254
Deficiency per linear feet of main pipe	$0.167

With every 85-foot lot there is an annual deficiency of $\frac{85 \times 0.167}{2}$ = $7.10 or $16.70 per 100 feet of street.

For income to meet the expense the guarantee instead of being 10 per cent or $0.24 per linear foot of street should have been $0.421 or $\frac{0.421}{2.40} = 17.6$ per cent.

It is to be noted that an income equivalent to 10 per cent of the cost of the extension $0.24 per foot per year is 1.4 cents per foot of pipe *less* than the cost of supplying water.

If the application is made to a privately operated utility entitled to earn a fair return on the capital invested, say 7 per cent, the guaranteed income should be even greater before the extension is

warranted as an investment, although it is recognized that due to franchise rights and protection extensions must be made when the return in every case does not appear to be sufficient. As an abstract proposition, however, the following is presented, subject to modification for individual application:

For purposes of illustration a plant valuation of $9,500,000 is used with plant condition and maintenance and operating expense the same as before and an annual consumption of four billion gallons:

Return on capital investment $9,500,000 at 7 per cent		$665,000
Return per 1000 gallons $\frac{665,000}{4,000,000}$		0.164
Maintenance and operation expenses, including interest and depreciation per 1000 gallons[4]		0.155
Total income required annually per 1000 gallons		0.319
Total income required annually per 100 cubic feet		0.239
Increase in rates for private company—$\frac{28.1}{15.5} = 1.8$		
Average cost of water per lot $10.80 × 1.8		$19.44
Required for interest and amortization on extension		7.10
Total		$26.54
Yield per linear foot of pipe line for 85 foot lot at $26.54 payment		$0.620
Interest and amortization payment	$0.167	
Cost of maintenance and operation	0.254	
Required to produce 7 per cent on investment $\frac{\$10.80 \times 0.164 \times 2}{0.155 \times 85}$	0.268	0.689

Yield is thus less than the requirement by $0.069, or about 11 per cent while the requirement is $\frac{0.689}{2.40} = 28.7$ per cent of the same.

But this yield is $\frac{0.62}{2.40} = 25.8$ per cent of the cost of the extension.

The examples seem to bear out the statement of Mr. Ledoux that an extension is not warranted unless the income in sight is from 22 to 44 per cent of the cost.

There are several drawbacks to the guarantee method of financing main pipe extensions, among which are: That the percentage of

[4] Estimated cost, Hartford (Conn.) Water Department, 1922.

cost of supplying water varies with any change in lot length and character of the premises served, and another is the absence of fluid balance between the cost of construction and water income, and still another is that after the amortization period the particular customers on this extension should have their annual payments reduced by the amount of the completed amortization payment, otherwise they are either helping to finance other extensions or are paying a higher rate than produces what is considered a fair return on the investment. Allowance for the completed amortization of the extension would result in complicated bookkeeping and a continuation of payments after the requirement had passed would make the consumer a furnisher of capital which is contrary to public utility rulings.

Outstanding thoughts in what has gone before are (1) The inequality of the method as between consumers of the same class, and (2) The fact that a utility, whether publicly or privately owned, is usually working at a loss when it makes an extension on a guarantee of less than 15 per cent of the cost in water rates or otherwise.

In effect also the increased rates from the guarantee amount in the end to payment for the extension and a much more simple way of meeting the requirement is by means of the assessment method in the case of a municipally owned utility.

The assessment method, however, is not nearly as simple as it first appears, for there are complications which arise due to exemptions for corner lots, street intersections and public or non-taxable property, also how much above bare cost of installation should be charged to the extension for general distribution works such as excess size of piping in main feeders. On the whole, however, the assessment method divorces two essentials which have no practical relation to each other, viz., cost of the extension into new territory and cost of supplying water. As a general proposition it appears that an addition of from a quarter to a third of the cost of the extension is usually necessary to take care of the exigencies of the distribution system, leaving the cost of additions to other parts of the plant to be met by bond issue when necessity arises.

In presenting the subject of payment for water main extensions under the assessment method it is not my intention to go very far into the theory of this means of financing public works and that matter will only be touched upon in so far as seems necessary in forming a basis on which to develop the more practical aspects of this subject.

Legal information is of course available in the codification of the laws of general government and of the several states. Opinions and decisions are to be found in the reports of the State Public Utility Commissions or similar bodies, and are most widely available in the Public Utilities Reports Annotated (Rochester). Most excellent treatment of a semi-legal character may be found in "Theory and Practice of Special Assessments" by Mr. J. L. Van Ornum Mem., Am. Soc. C. E.,[5] while more popular presentation may be found in an article on "Special Assessments" in the National Municipal Review.[6]

A careful analysis of the subject of assessments, particularly as relating to sewerage may be found in two dissertations by Mr. F. Herbert Snow, Mem. Am. Soc. C. E., one in his report upon a sewer tax for the City of Brockton, Mass.[7] and second a paper on "Sewer Assessments" before the Boston Society of Civil Engineers.[8]

While the matter of financing water supply work is not strictly analogous to that applicable to that of sewerage, still there is sufficient similarity to warrant close study of the methods developed in connection with the latter to make it worth while to give them consideration. The use of the property assessment processes for financing sewerage work is well-nigh universal and there seems to be no inherent reason why it should not be applied as well to water supply work. Undoubtedly at the beginning in most cases the municipality has bonded itself to raise funds for undertaking the work and in most cases also it is probable that for the first few years money at least for payments to sinking fund to amortize these bonds and perhaps also for interest on them comes from the tax levy.

The following excerpts seem of sufficient authority to attest the legality of the application of the method of special assessment for defraying the cost of the water main extensions by municipalities.

By definition an assessment is "the official apportionment of taxes." Taxes may be either general or special as the object is for the general interest or for the advantage of a certain portion or district. A special assessment has been defined[9] as "a compulsory

[5] Trans. Am. Soc. C. E., vol. 38, 1897, p. 336 et seq.

[6] February 1922. Publication by National Municipal League, 261 Broadway, N. Y.

[7] Journal Assoc. Engr. Soc., Jan. 1897.

[8] Report of the Sewerage Commissioners, Brockton, Mass., 1894.

[9] Quart. Jour. Econ., April, 1893.

contribution made once and for all to defray the cost of a specific improvement to property, undertaken in the public interest and levied by the government in proportion to the special benefits accruing to the property owner."

CITATIONS RE SPECIAL ASSESSMENTS

1. *Improvement must be of special local benefit.*

. . . . To make the special assessment valid, its purpose and effect must be to benefit the property in the vicinity of the improvement, and not to the public generally. . . . .

Ref.: 10 La. Ann. 57; 69 Pa. 352.

2. *Assessment in proportion to benefits.*

. . . . Burdens in excess of benefits . . . . must be borne by general taxation. . . . .

Ref.: 12 Colo. 593.

3. . . . . A lot, though below the grade of a sewer, has to pay its portion of the assessment, as it will be benefited whenever it shall be filled. . . . .

Ref.: 69 Texas 180; 7 Cush. (Mass.) 277.

4. *Details of Apportionment.*

. . . . Corner lots, having thus a double frontage, may be properly assessed the total amount determined by their linear extent on both streets, where both streets are improved; though the usual way is to abate a certain percentage of the assessment on one front, and there are cases where, when a corner lot has its longer dimension abutting on the improved street and its shorter dimension on another, it was held that the lot should be deemed as fronting on the improvement only to the extent of its shorter dimension, but the usual rule in such cases is that the frontage of a corner lot is "its frontage upon the improvement," although the condition of the lot and its improvements make its proper front (as usually considered in other connections) on the cross street. . . . .

Ref.: 35 Pa. St. 75; 32 Iowa 271; 140 Ill. 402; 50 Ohio 471; 131 Mo. 190.

5. *Principles Affecting the Validity of the Levy.*

. . . . The law must require notice to them and give them the right to a hearing and an opportunity to be heard. . . . .

Ref.: 74 N. Y. 183, 188.

6. . . . . The power of taxation, especially for local improvements, is the highest attribute of sovereignty. . . . . Such statutes must be construed with the greatest strictness. But in the absence of fraud or mistake the administrative acts and discretionary decisions of this Board are authoritative and final; and "The decision of the Board . . . . is conclusive." . . . .

Ref.: 4 Hill (N. Y.) 76; 59 Ark. 344, 363; 33 Minn. 295, 304.

7. . . . . There may also be a successful defense if there is no possible benefit to the property; as where the owner of a corner lot had applied to the city council for the use of water and had paid for the pipe laid in consequence along one front of his property, he was held not liable to assessment for pipe afterward laid along the other front without his petition. . . . .

Ref.: 14 Bush (Ky.) 24; 86 Pa. St. 498.

8. . . . . . Neither will the fact that a property owner, assessed for the construction of a public sewer, had previously constructed a private sewer (sufficient for the needs of his property and with the assent of the city) relieve him from such assessment, even when a municipal building had connected with the private sewer.

Ref.: 81 Wis. 326; 168 Pa. 105; 154 Ill. 23; 138 Ill. 295.

In the application of the method of special assessment the following conditions should be observed as being equitable and reasonable:

1. The Water Department should determine if the extension is required by public convenience and necessity and when so decided should establish a definite means for assessment based upon the average cost of laying a water main of proper size to supply both domestic and fire protection service to the street in question.

2. The Water Department (for the municipality) should pay that proportion of the cost which is for general benefit, usually from one-fourth to two-thirds the cost of the extension.

3. Two methods seem applicable for payment of the assessment:

(a) By a frontage tax against all abutting property which may be served by the extension.

(b) By an "entrance fee" for the privilege of connecting with the water main and based on lot frontage.

4. The assessment should be so regulated that the total amount may be paid in full or in installments during a fixed term of years at the option of the person assessed.

Because of the inequalities that were patent in the guarantee method, and because of the many complaints that were made both by house owners and local developers, the Water Department of the City of Hartford, Conn., has recently (Jan, 1922) changed from the "guarantee" to the "assessment" method of financing main pipe extensions. As a general proposition the plan has worked very well and there seems to be no cause for regret in the change. Some of the considerations leading up to this action were the following:

1. A lot of land increases greatly in value with the installation of a water main in the street on which it fronts. It therefore seems more just for the land owner to bear the cost of the improvement than for other water consumers throughout the city to be taxed for it.

2. This method tends to equalize the cost of the improvement by distributing the cost over all property benefited rather than, as under the old method, placing all of the burden on a few property owners.

3. A healthy development of real estate is provided by enabling a property owner to utilize his holdings without being held up by the expense of the water installation when other owners were reluctant or refused to sign a guarantee.

4. Real estate development is aided by making it possible for the owner to include equitably in the price of his lots the cost of the water installation.

5. By this means cost of supplying water and cost of water main extension are separated and each is apportioned to the consumer in proportion to value received.

6. The cost of the extension is recognized as a capital expenditure and can be properly met as such by a bond issue, with interest and sinking fund entirely met from the payment of the assessment, while the cost of supplying water, being an operating and maintenance charge, is met from water rates.

While there is no disposition to return to the abandoned method there are many problems that have arisen which are now in process of solution and a recitation of some of them may be of value in helping others to save time and trouble in avoiding them when the assessment method is adopted by them, as it seems probable it eventually will be.

The matter of what portions of the cost should be borne by department and by abutting property has been a cause of much discussion. The final decision was that the department would assume:

1. All cost in excess of the average cost of a 6-inch main.
2. The cost of street intersections.
3. The cost of the installation in front of public property.
4. The cost of 75 feet frontage on corner lots when there was a main on the other side.

Some questions which have arisen but probably have not yet been finally disposed of are:

1. Whether or not the corner lot exemption should begin at the actual property corner or at the building line where one is established.
2. Assessment against frontage of irregular lots when one end is so narrow as to be impracticable for building.

The authority under which this method for financing main pipe extensions is carried on is in an act of the General Assembly authorizing the Common Council of the City to enact an ordinance providing for it. This ordinance was as follows:

Be it ordained by the Court of Common Council of the City of Hartford;

Section 1. Whenever in the opinion of the Board of Water Commissioners of the City of Hartford, public necessity and convenience require the extension of any main pipe and shall vote to make such extension, said Board shall assess the cost of such extension against the land found by said Board to be specially benefited thereby abutting upon the road, street or highway in which such main is to be laid, with the buildings on said land, in proportion to the frontage of said land upon such road, street or highway.

Section 2. Before said Board shall vote to make any such extension at least ten days written notice of the proposed extension shall be given to the owner or owners of the land and buildings upon which the cost of such water mains may be assessed and of the time and place when objections to such extensions will be heard by said Board and notice thereof shall also be published twice at least, in two newspapers published in the City of Hartford.

Section 3. Upon the final completion of the construction of such water main, said Board shall give written notice thereof to the owners of the land and buildings assessed thereof and that said assessments are due and payable from the date of such notice. The amount so assessed shall be a lien upon the lands and buildings on account of which it was assessed, which lien shall commence and attach to said land and buildings from the time of the passage by said Board of the vote to extend said water main, but shall not remain a lien thereon for a longer period than three months from the final completion of said work unless said Board shall within that time lodge with the Town Clerk of the Town within which such land and buildings are situated for record, a certificate signed by the Secretary or other authorized representatives of said Board describing the premises and the amount assessed thereon.

Section 4. Said Board shall in no case vote to extend its main pipe in accordance herewith in any road, street or highway that has not been legally accepted by the city or town within which such road, street or highway is located or in any road, street, or highway until the same has been rough graded to an established grade.

Section 5. Said Board in determining the cost of any such extension shall use the average cost to said Board of laying six-inch pipe in the City of Hartford during the preceding calendar year provided that such average cost does not exceed the actual cost thereof.

Section 6. The owner of any land and buildings assessed for the cost of main pipe extensions as aforesaid may elect to pay the amount assessed as aforesaid in ten annual installments with interest on the unpaid balance thereof, provided that notice of such election shall be given to said Board within thirty days after notice shall have been given of the completion of the work.

After working under it for a year and with every effort made to keep cost of construction at a minimum it was found that the average cost of laying 6-inch water pipe was $2.35 per linear foot, including overhead. When it became necessary to establish the price for 1923 it was seen that prices of materials and labor were to be much higher than in the previous years and if the average cost for 1922 was made the basis for the ensuing year the department stood to pay a much larger proportion of the total cost than in the previous years. After some study of conditions it was decided to use the average cost for the previous five years. Working on this basis a base price of $3.00 per linear foot for the year 1923 was established and an ordinance enacted to this effect. Due in part to the oppor-

tunities of this method and in part to the lagging of ordinary building construction due to the high prices of the previous year there was something resembling a boom in building during 1922 and much main water pipe was extended.

The total cost of this work was $194,977 of which the Water Department absorbed $45,987 or practically one quarter, due to the various causes mentioned above. Besides this expenditure on account of capital, the Water Department also became the financial agent for promoting these extensions, finding the funds and carrying the investment until paid under the terms of the ordinance. It is readily seen that while a revolving fund would be created that in ten years at most would return sufficient to care annually thereafter for the new investment, yet up to that time the department must find the funds with which to finance the work. After some consideration the best plan seemed to be to issue serial bonds for a ten-year period. By this means interest and sinking fund would be met from the extension payment and in addition a substantial sum would be available at the end of ten years for current capital expenditures, the details of which on the basis of $150,000 annual bond issues are:

An annuity of $1.00 at 4 per cent compound interest in 10 years would accumulate $12.006.

$$\frac{\$150{,}000}{12.006} = \$12{,}493.75.$$

In round numbers $12,500 per year with interest at 4 per cent compound annually would in 10 years amount to $150,000.

Total interest paid in 10 years, $150,000 at 4 per cent	$60,000	
Total interest received on unpaid balance in 10 years	40,500	
Excess interest paid		$19,500
Received from assessments in 10 years	150,000	
Paid into Sinking Fund, $12,500 × 10 years	125,000	
Excess money received		25,000
Total excess received over amount paid in 10 years on each issue of bonds		$5,500

The guiding principle of this paper is intended to be the establishment of a sound business policy applicable to the plan of water department activity herein discussed.

A business which does not support itself in all its parts is in a sense parasitic and subsists because some of its portions pay the difference between cost and income. In present day management a business must support itself or be scrapped. The rights of a customer should be safeguarded, but it is not his right to get something for nothing which ultimately increases an unequal burden on some other customer. The necessity of payment for value received is often overlooked in rate fixing and uniform prices often produces disproportionate burdens that it was the intent to equalize.

As to the operation of the assessment method in Hartford, Conn., for the financing of main pipe extensions, table 1 is a résumé of of the method employed in 1922, with the relative distribution of costs between the work done by hand labor and that with a Keystone Excavator. Leadite was used in making the joints.

Allocation of the total amount of pipe laid in 1922 is given in table 2.

Exemptions and allocation of the amounts paid by the Board are shown below:

	MAINS COSTING LESS THAN $3.05 PER LINEAR FOOT	MAINS COSTING MORE THAN $3.05 PER LINEAR FOOT	TOTALS
Assessable frontage, feet	74,083	34,135	108,218
Exemptions, feet	5,858	5,731	11,589
Frontage exemption, cost	$7,011.66	$8,739.78	$15,751.44
Street intersections, cost	4,173.78	7,879.93	12,053.71
Oversize and construction difficulties (cost)		18,182.43	18,182.43
	$11,185.44	$34,802.14	$45,987.58

The method used during 1922 for ascertaining the amount of assessment was to determine the actual cost of laying pipe per linear foot by dividing the total cost of the work by the total length of water pipe laid, i.e., by the distance along the axis of the pipe, from the center of the pipe from which the extension was made to the extreme end of the new pipe line. After determining this unit cost it was divided by two (for application to both sides of the street) and the result multiplied into the respective lot frontages which were not exempt by vote of the Board.

By this method the cost of pipe laying in all street intersections and crossings, as well as in front of exempted property was assumed by the Board.

Exemptions have included corner lots up to 75 feet when there was a water main already laid by the other side, also property used for public purposes.

In addition to the above, the Board has borne the cost of all work exceeding the base price of $3.05 per linear foot whether the same was due to matters of construction, to the installation of pipes of larger size than the standard 6-inch, or to other abnormal conditions.

By this method it appears that approximately ¼ of the cost of the main pipe extension work is borne by the Water Department and ¾ of the cost by abutting property owners.

During the year, two other methods of apportioning cost have been suggested, both of which are based on placing the entire cost[10] on property abutting on the portion of the street in which the pipe is laid.

One of these methods would apply the total cost of the work to the same assessable frontage as at present; the other would distribute the total costs of the work over the total frontage with no exemptions for corner lots or public property.

Neither of these propositions will provide entire relief, namely, to place the whole burden of cost on the abutting property owners, because of the conditions that the *average* cost of laying 6-inch pipe the previous year is set as a maximum above which the cost must be carried by the department, while the abutter gets the benefit of cost below this limit.

This condition could be attained if the actual cost of pipe laying could be assessed against abutting property. This, however, brings in many complications which might lead to more trouble and possible expense for the Board than the present method. For example, it would be impossible to make even an approximate estimate of what would be the probable cost of the work without a very thorough investigation. Again, the cost of a 6-inch pipe extension seems to be as much as it is equitable to place on individual consumers, yet during 1922 only about 23 per cent of the pipe laid was of this size, the remainder being of larger size because of necessities of the service.

[10] Not exceeding base price.

TABLE 1

Summary of main pipe laid 1922

Detailed costs of pipe laid under assessment plan

SIZE	LENGTH	LABOR COST + 15 PER CENT		MATERIALS COST + 10 PER CENT		TOTAL COST	
		Total	Per foot	Total	Per foot	Total	Per foot
inches	*feet*						
6	14,751.2	$12,498.58	$0.85	$16,267.35	$1.10	$31,726.56	$2.15
8	42,238.8	42,151.74	1.00	72,055.35	1.705	125,729.39	2.98
10	2,272.2	3,117.72	1.37	5,868.21	2.58	9,884.62	4.35
12	3,665.5	6,645.79	1.81	12,400.44	3.38	21,282.67	5.81
16	872.0	1,791.62	2.055	3,950.73	4.53	6,316.59	7.24
Totals......	63,699.7	$66,205.45		$110,542.08		$194,939.83	

Note: Column 7 = Column 3 + Column 5 + 10 per cent; Column 8 = Column 4 + Column 6 + 10 per cent.

Amount assessed........	$148,989.97
Amount paid by Board........	45,987.58
	$194,977.55
Excess frontage assessment on west side of Dennison Street........	37.72
	$194,939.83

Total assessable frontage = 108,218 feet.

Comparisons of cost—machine vs. hand labor

SIZE	LABOR (KIND)	LENGTH	LABOR		MATERIALS		TOTAL COST	
			Total	Per foot	Total	Per foot	Total	Per foot
inches		*feet*						
6	Machine	9,658.8	$7,047.61	$0.73	$10,323.29	$1.07	$19,131.30	$1.98
6	Hand	5,092.4	5,450.97	1.07	5,944.06	1.17	12,595.26	2.475
8	Machine	22,824.4	19,911.87	0.87	39,127.78	1.715	65,094.87	2.85
8	Hand	19,414.4	22,239.87	1.145	32,927.57	1.70	60,634.52	3.125
10	Machine	1,347.4	1,429.74	1.06	3,267.07	2.425	5,166.59	3.835
10	Hand	924.8	1,687.98	1.825	2,601.14	2.81	4,718.03	5.10
12	Machine	1,807.1	1,976.29	1.09	5,719.34	3.165	8,565.12	4.74
12	Hand	1,858.4	4,669.50	2.51	6,681.10	3.595	12,717.55	6.84
16	Hand	872.0	1,791.62	2.055	3,950.73	4.53	6,316.59	7.24
Totals.....	Machine	35,637.7	$30,365.51		$58,437.48		$97,957.88	
	Hand	28,162.0	35,839.94		52,104.60		96,981.95	

While it would be perfectly logical to assess the total cost of laying a 6-inch pipe against abutting property, it would undoubtedly result in much discussion and many difficulties for the Board to settle, due to the extreme variation which might result from the character of the ground, whether rock, sand, water or other conditions. It would be somewhat difficult also to determine just what would be the cost of laying a 6-inch pipe when a larger pipe was laid under difficult conditions. Yet by the theory of assessments on property actual cost of work done for that particular piece of property may not be exceeded.

TABLE 2

Main pipe laid during 1922

Frontage, exemptions, etc.

	6-INCH PIPE IN HARTFORD ONLY	6-INCH PIPE IN HARTFORD AND WEST HARTFORD	ALL SIZES HARTFORD AND WEST HARTFORD
Total length of pipe laid, feet	5,753.8	14,751.2	63,799.7
Total frontage in feet	11,006	28,494	119,807
Exemptions:			
Street corner lots and public property	*1,514*	*2,264*	*11,589*
Assessable frontage	9,492	26,230	108,218
Street intersections	561	1,068	7,876

The following suggestions are made in a tentative way for financing the cost of a water supply system

1. Let the District bond itself for a sufficient amount to install the main features of the water supply system, such as collecting systems, pumping plant, purification plant, supply mains and similar features.

2. Let those who desire the water pay a benefit assessment equivalent to the cost of installing a 6-inch pipe to supply their property, whether or not the supply main passes their property and in proportion to the respective lengths of the several properties where there is more than one applicant, each previous contributor to get a proportional repayment as other takers come onto the line thereafter.

2a. A variant of this would be to take a guarantee from one who desired the extension that he would pay an amount annually equiva-

lent to 10 per cent[11] of the cost of installing a 6-inch pipe to serve his premises in addition to the water rents.

If there are any persons on the line of pipe unwilling at the time to sign the guarantee, refuse to allow them to connect thereafter until they do agree to sign to pay their share of the annual payment, proportioned on the number of feet property fronting on the street in which the pipe was laid.

No rebate should be given to previous guarantors, on the assumption that their previous payments were for value received at that time.

3. The proposed water taker should pay for the service installation from the street line to his house.

4. The Water District should pay for the service connection from the street main to the street line, and for the meter and its installation.

On this basis a guarantee is not sound financially unless it provides (using 15 years as a reasonable time for the cost to be amortized) for an annual payment of 5 cents on the dollar of investment, which is the amount which put at interest annually at 4 per cent compound interest will amount to $1.00 at the end of 15 years.

Payment made on this form of financing main pipe extension costs should be made in excess of water rents; i.e., water rents should not be allowed to be made a part of the payment for main pipe extensions.

Before leaving the subject of assessment as applied to financing main water pipe extensions it seems desirable to mention some of the water departments where this method is in use:

Philadelphia, Pa. (C. E. Davis, Chief of Bureau): "Philadelphia assesses property owners for water pipe laid in front of their premises at the rate of $2.00 per front foot, as per ordinance approved April 14, 1920."

Yonkers, N. Y. and other municipalities in this state (A. W. Kingsbury, Chief Clerk), Section 8, Art. VIII, Suppl. Charter 1918: "In addition to water rents provided for in this section there shall be a frontage tax of five cents a front foot in each and every year on all real estate lying along or facing either side of the street or alley in which a water main is now laid or shall hereafter be laid." This frontage charge has been upheld by the Supreme Court of New York.

Detroit, Mich., makes a charge of 25 cents a foot against abutting property as the abutters share of the cost.

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[11] The 10 per cent guarantee in addition to the water rents is based on 5 per cent interest on the principal and 5 per cent additional for a sinking fund to amortize the cost in 15 years at 4 per cent compound interest.

Minneapolis, Minn., assesses against abutting property owners one-half cost of laying a six-inch pipe.

St. Paul, Minn., assesses a charge of 10 cents per front foot per year against property for 10 years. (Note: at 4 per cent compound interest this payment would amount to $1.20 at the end of the period, equivalent to $2.40 per foot of pipe laid.)

Milwaukee, Wis. (H. P. Bohmann, Superintendent): "All assessments are based on the cost of laying a six-inch main. An estimate is made early in the year, after contracts have been let for water pipe, hauling and laying. Cost records are kept on each job. In case the cost of laying six-inch main exceeds the estimate made early in the year, the property is assessed only the amount fixed by the estimate—the difference being paid out of the Water Fund. When the cost is less than the estimate the property is assessed the actual cost of laying the main. Street and alley intersections are paid for out of the Water Fund. When larger mains are laid than six-inch the property is assessed on the basis of laying a six-inch main, the excess cost being paid out of the Water Fund.

"Corner lots are given a deduction of one-third of the two frontages."

Altoona, Pa., makes a frontage charge of 25 cents per front foot when the main is laid.

Pasadena, Calif., makes a frontage charge of 50 cents per front foot when the main is laid; the department bears the excess cost.

Jacksonville, Ill., and other cities of this state lay water mains under the same act as they do sewers and street paving, viz., the "Special Assessment Act."

City of Seattle, Washington, lays water mains under city ordinance which covers the method of laying assessments.

Duluth, Minn., assesses cost of water main extensions on the basis of a formula designed to make the construction self-supporting, assessing 8 per cent of the cost each year against abutting property for 15 years and crediting to this assessment one-half the rates paid for water.

Pennsylvania Water Company (W. C. Hawley, Chief Engineer) has a bonus system which seems to work out very well.

Decatur, Ill., finances water main extensions in accord with the State law out of a special assessment levied against property served.

Cleveland, Ohio (F. B. Crowley, Registrar): Water mains financed by special assessment against property deemed to be benefited under one of the following methods:

1. Percentage of the tax value of the property.
2. Proportionate to the benefits resulting from the improvement.
3. Front footage of property bounding or abutting upon the improvement.

Washington Suburban District, Md.: A logical and seemingly well worked out plan for financing both water and sewer cost has been applied by Messrs. Robert B. Morse and Abel Wolman of this Association, and is described by them in Eng. News-Rec., June 2, 1921.

"By this method the installation of both water supply and sewerage systems is paid for by a combination property tax, annual front foot assessment, house connection cash payment, meter service charge and water consumption charge."

APPENDIX "A"

Water main assessments for extensions—corner lots

1. Reading, Pa. Corner lots, exempt ½ of the assessment on total length on both streets.
2. Bristol, Conn. Exempts 100 feet on total length.
3. Philadelphia, Pa. Exempts ½ the length of one of the fronts, but in no case shall the allowance exceed 50 feet on any corner lot.
4. Washington, D. C. Exempts 100 feet on total length.
5. Milwaukee, Wis. Exempts ½ the length on both sides.
6. Allentown, Pa. Exempts ½ on the longest side, but in no case shall the allowance exceed 60 feet.
7. Minneapolis, Minn. Assessment laid against long side, short side exempt up to 65 feet. Full payment made on side first covered and adjustment made when other side is covered.
8. St. Paul, Minn. Short side only assessed.
9. Washington Surburban Sanitary District. Assesses only on side the building faces.
10. In some cities no exemption is made on corner lots.
11. Hartford, Conn. Sewer Assessment—Short side assessed, long side exempt up to the normal depth of lots in the section, say 125 to 175 feet.

APPENDIX "B"

Extracts from Page and Jones "Taxation by Assessment"

Art. 11, p. 19, Special Assessments: "It is a local assessment imposed occasionally, as required, upon a limited class of persons interested in a local improvement who are assumed to be benefited, and it is imposed and collected as an equivalent for that benefit and to pay for the improvement." City of Bridgeport vs. N. Y. N. H. & H. R. R., 36 Conn. 225, 262, 263, Am. Rep. 63 (T869).

"The foundation of special benefits for public improvements is the special benefit derived by owners of property over and above the rest of the community." Newell vs. City of Cincinnati, 45 O.S. 407, 424. 15 N.E. 196 (1887).

Art. 668: A general conservative rule as regards special assessments authorized by the legislature seems to be that "the legislative allocation is to be regarded as final and conclusive except as to cases where actual injustice is shown to exist and where assessments are levied greatly in excess of or out of proportion to the actual benefits."

Art. 670: The legislature may leave it to the public Corporation which is to levy the assessment to determine the method. In that case "it has been said that the public corporation is restrained only by the constitution and laws of the State and by the doctrines of the common law which requires municipal ordinances to be reasonable."

When the legislature provides that the question of the existence, amount and apportionment of benefits shall be determined by the public corporation which is to levy the assessment or by some designated public official or set of officials, it is said in many cases that the determination of said public corpora-

tion or public officials upon the question of the existence, amount and apportionment of benefits is final and conclusive.

Art. 708: Assessments of a fixed sum per front foot have been applied as long as they do not exceed the cost of the improvement.

Art. 709, p. 1229: "If land on one side of the street belongs to the county and cannot be assessed, the entire cost of improving such portion of the street cannot be assessed upon the land on the opposite side of the street."

DISCUSSION

CALEB MILLS SAVILLE: I think the method of assessments has given very good satisfaction. It is apparently more pleasing to the people than the guarantee method has been, for several causes. Under the old guarantee method when a man built a house or owned a lot 1000 feet down a new street from a water main, he would petition to have a water main laid in that street, guaranteeing 10 per cent of the cost in water rents or otherwise. He might go to various other owners on the street and ask them if they would sign the petition with him. Some would sign and others would not. In consequence the signers might have to bear the whole burden of the guarantee while the other property owners had the benefit without the obligation, because when the main was laid it became public property.

A MEMBER: Does your department collect the funds or is it done through the city?

CALEB MILLS SAVILLE: Answering the gentleman's question, we collect all the funds and have the use of them. We are practically a private corporation. We have a charter of our own, although it is a municipal corporation. The only connection we have with the city is that each year the Mayor appoints two members of the Board who are confirmed by the Council; after that the board functions independently, using all its funds as it deems proper, and can sue and be sued. If we change the rates, they have to be approved by the Council, as does also the bond issue, which becomes then an obligation on the city.

The method applies to extensions inside the city limits, everything that we have jurisdiction over; there are one or two communities that we supply on the same terms and conditions that we supply our own. There are one or two communities in which

our water supply reservoirs are located and under our charter we are required to furnish them with water on the same terms as the city. We do our work entirely with city employees.

As to payment for laying pipes in the newly annexed territory which has to be supplied with water facilities, we supply it through a master meter at the city line the same as to any private consumer. If the section is annexed to the city and becomes an integral part of the city, we make an appraisal of the local works and the Hartford Department purchases the system. In the case of an annexed section having no water mains, we should go on the same basis that we would in the city. That would be a part of the city and we should lay pipe in it and assess against the frontage.

Each frontage is assessed separately irrespective of the owner. This applies, of course, to property annexed to the city. Property outside the city is cared for as hereinbefore described.

If anyone assessed refuses to pay an assessment, a caveat is filed as soon as the Board decides to put the pipe in. A period of three months may then elapse and after that a lien is applied that takes precedence over everything.

Answering Mr. Gibson's question how we determine when an extension is to be made, that is a question that lies with the Board of Water Commissioners. A public hearing is held; ten days notice is given by advertisement of a public hearing and everyone for or against is warned to attend that hearing. The Board then takes it under advisement, and if, in the judgment of the Board that pipe should be laid, it is laid. The determining factor is only in a partial degree the economic return to the department, as the property pays for most of the improvement. The only matter of vital interest to the Board is a prospective return sufficient to take care of the portion of the cost absorbed by the Board. The money collected is credited to capital account.

Answering Mr. McIntyre, it is a law that was passed by the legislature amending the charter of the city of Hartford, Connecticut, for the purpose of doing this very thing. It is also a state law in many other states; Washington, I think, has such a law, and a great many of the states in the middle west have such laws. There are quotations in the body of the paper as you will find.

S. L. Etnyre: The Iowa water works and the Iowa Section of the American Water Works Association have a very similar bill before

the legislature at the present time. As I understand the gentleman speaking, there is no refund.

Caleb Mills Saville: No.

President Cramer: That is another proposition than the one we have been talking on. There is no refund whatever, just simply an assessment against the property.

Henry P. Bohmann: Milwaukee has laid 600 miles of water mains and has collected in round figures approximately $3,000,000 from the abutting property owners for water pipe assessments. This represents the extension of the system during a period of 50 years, and in no instance has any property owner during the 50 years ever attacked this assessment. An estimate is made at the beginning of each year of the cost of laying a block of minor water pipe, which is a 6-inch pipe. After contracts are let for water pipe and the laying of same, this estimate is made. When the water main is laid, and the actual cost exceeds this estimate, the difference is borne by the water department. If the cost is less then the abutting property owners pay the actual cost. All street intersections are paid for out of the water fund, and the excess cost of laying the mains, if larger than a 6-inch main, is paid out of the water fund. Corner lots are given a reduction of $\frac{1}{3}$ of the two frontages. Extensions are made at the request of any property owner and it does not require a certain percentage of street frontage to have this extension made. The Commissioner of Public Works introduces a resolution that the main be laid. The main is then laid and the assessment placed on the tax roll, together with other assessments and the assessment for the property. This has proven very satisfactory; no one has ever attacked the assessment, and it seems to me after an experience of fifty years in the city of Milwaukee that we must assume that it is pretty nearly right.

H. F. Blomquist: There are two different principles involved in the question: One is to finance water main extensions by ordinary special assessments as are made for other local public improvements, the other, to pay for extensions out of income from water sales. Many states permit municipally owned water works to make special local assessments against benefited property for such extensions, and this method is extensively used. Some cities make direct

special assessments, and others collect frontage tax for a period of years. The laws of the State of Iowa do not now permit special local assessments for this purpose, but permit tax levies to be made uniformly on all property of the city as a part of the budget for city government expenses. Water main extensions in Iowa, therefore, must be made from the income for water service, or from tax levies spread uniformly over the whole city. The latter is not much favored because it taxes property promiscuously for the benefit of some local section. Extensions in our state have, therefore, most commonly been paid for by income from the sale of water.

When construction costs increased, as they have the past few years, and cities increased in population faster than before, making a greater demand for water main extensions, it became difficult to finance them. To help overcome this difficulty a bill was introduced in the Iowa legislature as explained by Mr. Etnyre but failed to pass. The proposed law was worded so that it would be possible to make the change rather gently from the old way of financing by income from sale of water, to that of special assessments. It really did not propose special assessment as the ultimate means of financing as I shall explain later.

It might seem to be unfair discrimination to commence arbitrarily to make property owners pay for main extensions by special assessments, also charge them the same rate for water as others who have formerly had the mains laid in front of their property at the cost of the water department.

In new additions the income from water sales for many years, sometimes, is not sufficient to pay interest charges on the necessary investment. But platted vacant property in a city is generally increased in value as soon as water service is available, because of better chances for sale and development.

The purpose of the proposed law was simply to provide that vacant property should carry its portion of the investment for water mains, until it had a water consumer on each lot. The wording in substance, was as follows:

When water main extensions are made by municipally owned water works, an assessment may be made against the benefited property not to exceed the cost of laying a six-inch water main in front of said property, and later the municipality may refund to the owner when he becomes a water consumer, the amount paid of such assessment not to exceed the equivalent of 50 feet of frontage for each connection.

The effect would be that owners of vacant property would carry the investment in water mains fronting on their property until a connection is made for each 50 feet of such property. Many operators in Iowa feel that it would solve the problem of financing main extensions in sparsely settled additions, and still adhere to the principle now in use of paying for them from the sale of water.

Caleb Mills Saville: A municipal water works is, theoretically at least, supposed to sell its water at cost. Selling its water at cost means practically no profit, and having no profit, theoretically again, there seems to be no way where you can find the money to finance your main pipe extensions. If there is a profit, it seems to me that there is discrimination, because you are making all your consumers pay for pipe that you are going to lay in front of some other man's property and be a special benefit to that property at the expense of the other water takers.

John N. Chester: I do not think Mr. Saville, if he would analyze his last statement, would make it. There are numerous municipalities that make a profit on their water. The cities of Erie, Pa., Shreveport, La., and Meridian, Miss., all sell their water at a profit, and it is easy to justify, at least, the annual depreciation on the plant, set aside as a depreciation fund to be reinvested in the extension of the plant. That is good business in private affairs, and anything that is good for a private concern ordinarily fits fairly well in a municipality. Now Mr. Hazen was the author of the statement once made before this Association that he had never yet looked into the affairs of any water department, private or municipal, that was not starved financially, and he always expected to find them so when he found low rates being charged. That is about as near Mr. Hazen's words as I can quote. It coördinates absolutely with my experience, and I do not believe that any water department ought to operate without sufficient rates to pay its operating expenses, interest on all bonds outstanding, the sinking fund on bonds outstanding, and a reasonable amount for ordinary extensions which you can call depreciation or what you may.

P. J. Hurtgen: Mr. Bohmann, of Milwaukee, told you of the manner in which they made assessments in Milwaukee. Milwaukee is the only first class city in Wisconsin. There is on our statute

books a law that was passed two years ago which provides that cities other than cities of the first class can assess for water mains to the extent of the cost of a 6-inch main. Up to two years ago, the extension of water mains was financed by the Water Department, and this year we started for the first time to make assessments based on the cost of a six inch main. That is virtually the same plan Mr. Saville outlined to you. What the Legislature had in mind in passing this law I do not know, probably they were following Milwaukee's plan; but I think it is a fair way to handle the situation. Our cost last year on a six inch main was $1.60 per foot and we are assessing 80 cents a foot against the property on each side of the street. Assessments are made for benefits, and while the law does not make any provision as to how corner lots shall be treated we are treating them the same as Milwaukee; on the short side of the lot where the main is laid, the full frontage is charged; on the long side we deduct one third of the sum of the two sides. Because of the fact that this is the first year we put this into effect the Water Department is going to finance the proposition in two year payments. After the main is constructed, by the way, we construct all our own water mains by city labor, we send out a thirty day notice that their assessments are now due and payable, and if not paid within thirty days, 6 per cent interest will be added, so that the first payment, if not paid in cash, will be entered on the tax roll the first year, and the second payment the second year. That is the way it is being handled in Kenosha.

James E. Gibson: The matter of assessments seems to be one of local conditions. There are so many different ways of reaching the same end. In our case at Charleston, the private water company was organized in 1876 and made the extensions on the order of the City Council. In 1917 the city purchased the plant placing it under the management of the Commissioners of Public Works. This Commission is organized under a state charter and is independent of the City Council. Immediately after the organization of the Commission we had requests for extensions of mains in this and that section, and upon our refusal we were met with this argument, "I helped float bonds with which to purchase the plant and I am paying interest on these bonds. Why should Mr. Smith on Broad Street have a water main and be able to obtain water in his house while my property in the north west section of the city

has to go without water?" The Commission adopted a general ruling that the policy of the Commission would be to lay mains in all streets in the city of Charleston, first on those streets that were built up and in which the revenue would warrant a reasonable return on a 6 inch pipe, and continue the laying of mains as fast as the other portions of the city built up and upon the same basis.

If a party owns property and wants to develop it in advance of the natural growth, we will extend out mains into this development laying not less than a 6-inch main. A regular contract is made and an estimate prepared as to the cost of making this extension and the land development party pays the amount of this estimate over to the Commission and at the same time signs a contract which provides that the Commission will return him each year an amount dependent upon the number of consumers that are connected on to this extension; these refunds to be made during a period of ten years. No interest is paid on the cost of the work and should the amount returned the development party at the end of ten years not equal the cost of the extension then all accounting ceases. If the cost of the extension is refunded to the party previous to the expiration of the ten years, then the contract is cancelled and all accounting ceases, the idea being to return the cost of the investment without interest to the land company. However, if the development does not pay within ten years it is considered a bad investment. During the past six years we have made twenty three such contracts, and in ten of these contracts one-half of the money has been returned to the development company within the first three years. The entire schedule is working out very nicely, and we have very little complaint and the question of extending mains to one party and not giving similar service to another has been entirely eliminated.

As to bond issues; the more I see of bond issues the less I like them, and I am beginning to be a strong advocate of the "Cash and Carry Plan." We had a discussion this morning about trade wastes, etc., and we are simply saddling posterity with the bill to pay at the end of 25, 30, 40 or 50 years. I think we should take care of our immediate troubles and let the future generations take care of their vast undertakings. They are going to have plenty to pay and my experience for the last twenty five years is that we are paying more and more every year, and I want to endorse what Mr. Chester has said, "What is good for the private company is doubly good for the municipality."

J. M. DIVEN: Mr. Gibson endorses Mr. Chester's statement, which is in effect that the affairs of a municipality should be conducted the same as a private company; but he is not entirely consistent, for he opposes bond issues to finance water works construction and advocates the "pay as you go" theory. Water companies must depend on bond sales or stock sales to finance all construction as under state commission regulations they are not allowed to charge water rates high enough to create a fund for extensions and improvements. Nor are they allowed, in any case that the speaker knows of, to assess abutting property for the cost of laying a main in front of it. They must raise capital as any business concern has to raise it. If they cannot sell stock or bonds they must use the money that the capital they have put in earns, earns at reasonable rates and according to most state commission regulations as a reasonable return on the investment. That means that their earnings are reinvested in the business by compulsion, as they must supply the demand for water and for extensions to supply water, must keep up with the growth of the city whether they get cash returns on their investment or not.

To the speaker it always seemed strange that municipal business should not be conducted exactly as private affairs are conducted. For a city water works the capital, raised the same as for a water company, except that there could be no sale of stock, must all come from bond sales.

THE COÖPERATIVE TREATMENT OF THE ELECTROLYSIS PROBLEM AT COUNCIL BLUFFS, IOWA, AND OMAHA, NEBRASKA[1]

By P. H. Patton[2]

It is common practice to speak of electrolysis when we mean "stray current electrolysis." We engineers should, however, remember that there is a second division of the subject; that is, local action produced by and known as "soil corrosion."

Your Association has given some consideration to this question from time to time for approximately thirty years. I find among the earliest literature references to a paper by Charles A. Stone and Howard C. Forbes in the New England Association's proceedings, 1894–1895, then among the latest a paper by E. R. Shepard[3] before your Illinois Section at Decatur, in March this year.

We have experienced trouble from stray current electrolysis in Omaha since 1892–1894, as illustrated by the photograph of cast iron, wrought iron and lead water and gas pipes made in 1894. Professor Father Joseph Rigge of Creighton University made a careful study and report of these conditions to the Omaha Board of Public Works at that time. (See figure 1.)

The telephone plant with which I have been associated during the above period also suffered from electrolytic destruction of some cable sheath.

Various more or less effective remedies were applied by the Water, the Gas, the Telephone, the Electric and the Telegraph Companies, as they placed underground cables. Each interest was looking out for No. 1 without much regard for his neighbor and at that time without much help from the Electric Railways. Later, when the Electric Railways consolidated and erected a central steam power

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] Division Supervisor Plant Methods, Northwestern Bell Telephone Company, Omaha. Chairman Omaha and Council Bluffs Electrolysis Committee. Secretary Nebraska Joint Committee on Physical Relations between Electric Supply and Signal Lines.

[3] See Journal, July, 1923, page 603.

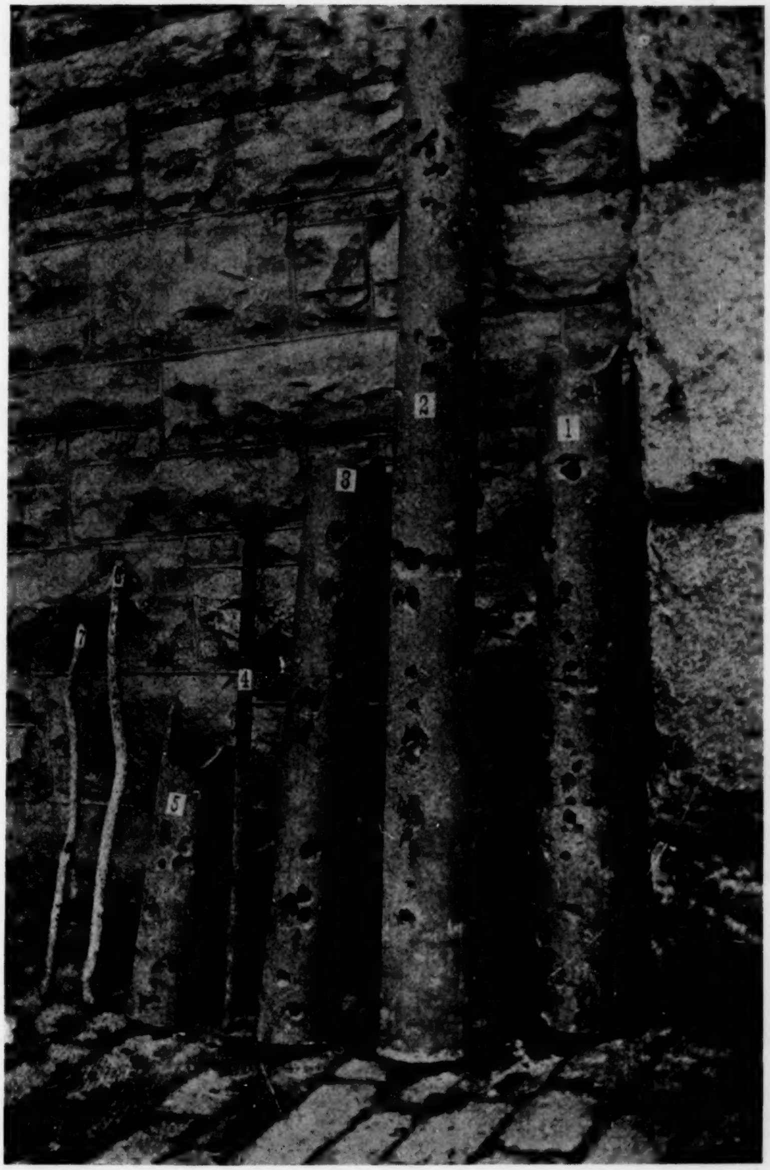


Fig. 1

Specimens 1 and 3. Taken up at 20th and Nicholas Streets, about 60 feet north of power house.

Specimens 2 and 5. Sections of same pipe, about 60 to 100 feet further north.

Specimens 1, 2, 3 and 5. Eight-inch water main.

Specimen 4. One-inch gas service of iron.

Specimens 6 and 7. One-inch water service of lead.

plant on the Omaha side of the Missouri river within a few hundred feet of the Electric Light and Power Company's plant, a very unbalanced system of current drainage developed, because it was a very easy matter for the Electric Light Company and the Railway Company to increase their bond to the Railway negative bus and unload all the stray currents their cable sheaths might pick up.

The other underground structures did not center at Jones street and the river bank, and their problem was becoming increasingly difficult with the growth of the city.

This was the situation in 1915 when our attention was attracted to the valuable work of the United States Bureau of Standards, which had begun a serious study of electrolysis about 1913 and had already published two or three bulletins on the subject. Early in 1916 the Omaha Technical Club arranged with the Bureau of Standards to have their Mr. Burton McCollum speak before the club on the activities of the Bureau with specific reference to electrolysis surveys and mitigation. This served to bring the matter to a focus and the Metropolitan Water District, the Omaha and Council Bluffs Street Railway Company, the Omaha Gas Company and the Nebraska Telephone Company joined in a request that the Bureau send a representative to supervise a survey. Later the Council Bluffs Water Department, the Western Union Telegraph Company, the Postal Telegraph Company, the Omaha Electric Light and Power Company, with the Citizen's Gas and Electric Company of Council Bluffs, assisted to a limited extent in the survey work, done under the auspices of the Omaha and Council Bluffs Electrolysis Survey Committee.

The Bureau's formal report was submitted in January, 1917, and it included a recommendation that a permanent electrolysis committee be formed to carry out the other features of the Bureau's report. I am quoting this Committee's recommendation in full, since it really is the Constitution and By Laws of the Omaha and Council Bluffs Electrolysis Committee:

> In order to prevent a recurrence of the present objectionable system of competitive drainage and to provide for regular and systematic measurements relative to electrolysis conditions, it is recommended that a permanent electrolysis committee be organized consisting of a least one member from each of the utility companies concerned; the duty of which committee should be to establish and maintain unified, non-competitive drainage on the several underground systems and to see that this drainage is limited to the smallest practicable amount. The committee should also make periodic measurements and

keep generally informed regarding electrolysis conditions in the Cities of Omaha and Council Bluffs. It is suggested that, as far as practicable, the members of the committee be technical men, and that they be given the power to act collectively, thus reducing to a minimum the necessity of referring back to higher authorities minor questions which may come up from time to time.

Mr. George T. Prince, then Chief Engineer of the Omaha Metropolitan Water District and well known to most of you water men, served as Chairman of the Committee the first year or two. The Electrical Engineers of the Railway Company have performed the duties of Secretary and Treasurer continuously and the speaker has acted as Chairman since Mr. Prince resumed private practice.

After organization, the Committee carried out the principal recommendations of the Bureau as follows:

1. The voltage gradients in the negative return circuits were reduced by these methods:

A. The placing of some additional insulated negative return feeders.

B. The establishment of sections of negative trolley wires and feeders. (The so-called "three wire system.")

C. The provision of a power substation (automatic) in Council Bluffs, where approximately half of the current had been returning by irregular routes.

D. Drainage was reduced and controlled by rheostats.

2. The Committee agreed upon a prorate of its annual expenses to be based upon the approximate mileage of track or trench in their sub-surface systems. This expense now averages $1500 per year.

3. The Committee arranged to maintain 40 potential taps to the rails, renting several miles of wires from the Telephone Companies for the purpose of bringing all taps to a central point where continuous use is made of these taps, readings being made on recording meters. This has been helpful in securing a high standard of rail joint bonding.

4. The Committee makes an annual coöperative survey of the potential differences between the various underground structures, using in rotation about 20 per cent of the stations established in the original survey and some additional stations where extensions have been built.

In order to maintain an active interest and prevent the matter becoming merely perfunctory, we have found it desirable to hold monthly luncheon meetings on regularly predetermined dates, with special meetings as required. This system has resulted in twenty-six meetings during the last twenty-four months. This monthly contact takes care of current routine matters and bills and also results in a general exchange of information as to proposed system changes and extensions.

We have succeeded in reaching equitable and agreeable conclusions in all matters so far handled, but we, as a committee, have

avoided any references to or discussion of the legal aspects of our cases.

The apparent success which attended the efforts of the Committee during the first two years of its existence was so marked that the interests which were reluctant to join at first came in whole-heartedly, and the work now has the unanimous support of the utilities maintaining metallic underground public service structures in Omaha and Council Bluffs. The roster of membership as shown on our letterheads and the present prorate of expense is:

Northwestern Bell Telephone Company	15.36
Nebraska Power Company	13.44
Metropolitan Utilities District:	
Includes Omaha Water Plant	16.32
Omaha Ice Plant	
Omaha Gas Plant	16.32
Western Union Telegraph and Cable Co.	3.00
Postal Telegraph Cable Co. of Nebraska	1.00
Omaha and Council Bluffs Street Ry. Co	23.04
Council Bluffs Independent Telephone Co.	3.84
Citizen's Gas and Electric Company	3.84
Council Bluffs City Water Works	3.84

The Omaha and Council Bluffs investigation was not published as a Bulletin by the Bureau of Standards partially because of lack of funds. Each participating utility was, however, furnished a complete set of reports and I have here a copy for your inspection. The more unusual features of our situation have been referred to in your Association several times, the most recent reference being Mr. Sam L. Etnyre's discussion of E. R. Shepard's article[3] in your JOURNAL.

The following magazine articles also were based on some features of the Omaha and Council Bluffs Electrolysis Committee's work:

"Line Drops and Rail Potentials Reduced by Three-Wire System in Omaha." E. H. Hagensick, Elec. Ry. Journal, November 10, 1917.

"Sectionalization of Overhead Wire for Three-Wire Operation." E. R. Shepard, Elec. Ry. Journal, December 8, 1917.

"The Automatic Substation in Electrolysis Mitigation." E. R. Shepard, Electric Railway Journal, April 30, 1921.

Mr. Corcoran's paper,[4] on the relation of water works to fire insurance rates, before this meeting, brings to mind the fact that

[4] This Journal, page 79.

the National Board of Fire Underwriters in the preparation of their Report No. 63 on Omaha and No. 228 on Council Bluffs took quite an interest in our Committee activity and endorsed the results that we have attained in the above reports.

In addition to the above articles, any of you who are interested in a detailed study of the technical aspects of electrolysis may obtain from your National Association a copy of the 1921 Report of the American Committee on Electrolysis. This report includes quite a complete bibliography of the subject which should be helpful in your further studies.

In addition to the photograph previously mentioned, I have here a gas service destroyed by stray current electrolysis and a piece of lead telephone cable sheath showing marked electrolytic effects. This telephone cable was in service from about 1893 until about 1916. We believe the damage was done about 1894–1895 but the remedial measures applied then stopped further losses. The lead sheath was still sufficient to prevent the entrance of moisture, consequently the wires in the cable were serviceable while undisturbed. However, upon removal, we found a considerable loss in weight of lead salvage.

While stray current electrolysis is largely a result of ground-rail return street railway systems, it is not safe to assume that the absence of street railway tracks gives immunity. Any grounded direct current electrical system may produce destructive electrolysis. We know of one town in Nebraska where a direct current three wire 220 volt lighting plant operated grounded and ruined the underground cable sheath of the local telephone plant.

SOIL CORROSION

This subject is an important one especially in cities with considerable areas of "made ground" or with cuts and fills which intermingled the various soils.

Our Omaha and Council Bluffs Committee has been coöperating during the last two years with the American Committee and the Bureau in their soil corrosion study. We have buried at Omaha 80 pipe samples in Knox silt loam and another 80 in Wabash silt loam. There are six sets in each soil and during the next six to ten years a set will be unearthed from time to time, carefully tested and weighed. Similar work is under way in more than forty places in the United States.

I have here a sample of corroded ⅜-inch gas-pipe as proof of the fact that local action or self-corrosion may take place inside modern concrete buildings. To reduce dead weight, cinders are sometimes substituted for gravel, or crushed rock in concrete fills. In an Omaha building where such a fill had been used between the ceiling and roof slabs, a gas leak developed and was traced to this pipe. This particular piece does not show a puncture, but several deep pits.

I believe Mr. Knouse, when inviting me to present these remarks to you, had in mind that I emphasize the coöperative feature of our work the last six years. I feel that our Committee exemplifies the success of the four "C's", a slogan promulgated throughout the Bell System by Mr. E. K. Hall, Vice-President of the American Telephone and Telegraph Company. The four "C's" are: Contact, Conference, Confidence, Coöperation.

Another member of our Committee has said that we have succeeded in substituting coöperation for competition, referring to our former disastrous competitive draining return system. Still another member says we are succeeding by substituting Mitigation for Litigation in approaching the problem.

THE RELATION OF WATERWORKS TO FIRE INSURANCE RATES[1]

By Harry J. Corcoran[2]

One of the two principal functions of a water supply system is to furnish water for the extinguishing of fires. Every superintendent is anxious to furnish the best service possible and to have his community receive maximum benefit in fire insurance rating. The methods used by insurance organizations in determining the value of a system must therefore be of considerable interest to this organization. It is hoped that this paper will present information which will be of use in operating and planning additions to existing systems.

Water is applied to fires through both public and privately owned equipment and different methods are used to measure the suitability of the service for each type. In this territory the National Board of Fire Underwriters Standard Grading Schedule is used to grade the system in connection with the public fire department. The rules of the National Board of Fire Underwriters and the Central Actuarial Bureau are used in grading the value of service for supply to privately owned automatic sprinkler equipments.

A general consideration of the Standard Grading Schedule is necessary to understand properly the relative part the water supply bears to the complete fire fighting facilities. The schedule is based upon the plan of assigning to the various features of fire defense found in cities, points of deficiency dependng upon the variance from standards formulated from a study of conditions existing in approximately 500 cities. The maximum total charge possible is 5000 points which represents no protection against fire. The maximum charge which could be made for lack of a water system is 1700 points; this is the greatest value assigned to any single department, the Fire Department being next with a maximum charge of 1500 points. Cities are divided into ten different groups called classes;

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] Chief Engineer, Iowa Insurance Service Bureau, Des Moines, Iowa.

no protection is called Class 10, and as protection is improved the class number is reduced, the differential being 500 points. This makes the water supply equivalent to 3.4 classes. In compiling insurance rates, all charges for hazards in buildings are added to a base rate; this base rate is determined by the class of public protection and the better the protection the lower the base rate.

A water system is examined on three points: viz., adequacy reliability and pressures; thirty-two items are considered independently and the sum of the individual charges determines the relative class of the system. A gravity system in which water is delivered direct from the source to the city is the ideal for fire protection, but a properly safeguarded pumping system is thoroughly reliable. In general, such duplication of parts of the waterworks is required that with those parts out of service, which may reasonably be expected to be inoperative, the system will still be able to furnish required fire flow. The introduction of storage, either elevated or for suction supply, offsets the need of duplication in those parts of the system through which storage has passed; storage sufficient for ten hours fire flow and five days consumption is assumed as offsetting need of duplication. In estimating required fire flow, an allowance is made for probable loss from broken connections incident to a large fire, experience frequently being that one-third of the water delivered to hydrants never reaches the fire.

The quantity required is determined by formula based on population, the gallons per minute being $1020 \sqrt{P}\ (1-0.01 \sqrt{P})$, P being the population in thousands; this is the quantity estimated as necessary to control a serious block fire in the mercantile district or two simultaneous fires of considerable magnitude. Smaller quantities are required for districts outside the principal mercantile district. This exceeds the quantity recommended by Kuichling, Freeman and other eminent engineers, probably due to allowance for waste and advance in equipment for handling fire streams. In towns and cities larger than 2500 population supply should be sufficient to maintain fire flow for ten hours in addition to domestic consumption. Measurement is made on the ability of the system to deliver fire flow at any pressure down to 20 pounds, this being the minimum pressure at which supply is of value for fire streams. The ability to deliver water at pressures sufficient for direct hydrant streams is credited to offset lack of fire department pumping engine capacity; for direct hydrant streams 75 pounds residual pressure

at hydrant during flow is necessary for 4-story buildings, 60 pounds is satisfactory for 3-story buildings and 50 pounds for 2-story buildings and in residence districts.

Under adequacy the normal ability of supply works to maintain domestic consumption demand and fire flow is considered. This includes impounding reservoirs, collection galleries or wells, filters, intakes, suction lines, pumps, power supply, air compressors, force or supply mains and storage. Flow tests are made at various locations to determine the capacity of mains in the distribution system. Variation of supply from wells or runoff at different seasons of the year is also considered. Adequacy is deemed of first importance.

In arriving at the reliability of the system, each step or operation necessary in delivering water from the source to hydrants is treated separately. All pumps should be duplicated and a heavy charge is made if maximum capacity of the plant cannot be continued with the largest unit out of service; absolute safety requires sufficient reserve to maintain maximum operation with two pumps out of service. Where water passes through two or more sets of pumps in series, charges for each set are totaled, with allowance for storage. The importance of large clear water storage in connection with filter plants is obvious. Duplication of boilers, electric generators, oil engines or other power units is graded in the same manner as pumps. Steam engines and motors are considered an integral part of pumps.

The condition and arrangement of pumps and power equipment is judged with a view to efficient operation and ease of repairs. The following forms and combinations of plant equipment, if of proper design and well installed, are assumed as approximately equal, advantage if any being in the order given:

(a) Centrifugal or reciprocating pumps driven by steam engines.

(b) Centrifugal or recriprocating pumps driven by electric motor.

(c) Pumps operated by water power.

(d) Centrifugal or reciprocating pumps operated by internal combustion engines suitable for the service. Service record in the plant under consideration and in similar plants is studied in arriving at an opinion.

Sufficient fuel should be kept on hand for five days consumption. Steam lines, oil piping, electric transmission lines, and boiler feed lines should be so arranged that the renewal of a valve, transformer, oil or boiler feed pump, will not prevent maintaining full supply of water for two days.

Pumping stations and power plants should be of fire-resistive construction or equipped with an automatic sprinkler system. First aid fire fighting equipment and connections for the fire department are advantageous. The building should be protected from exposing structures. Hazards such as heat, electric wiring and control devices, oils and oily waste, and chemicals must be safeguarded.

Reliability of supply mains is considered both upon the possibility of a failure and the effect of a failure. Duplication is required to such a point that a single failure will not reduce the amount of water delivered nor seriously affect the pressure. All pipe lines necessary to continued operation are included under this heading. Concrete or masonry aqueducts substantially built are assumed dependable enough not to require duplication. A charge is added where the most serious failure would occur in a long line. Cast-iron, wrought-iron and wood-stave pipes have been found satisfactory in various places when well installed. Mains should not endanger each other, and their failure at stream crossings, at railroad crossings, in filled ground, and at other points where physical conditions are unsatisfactory should be guarded against; ease of making repairs is taken into consideration.

In connection with supply mains arteries and secondary feeders extending throughout the system are necessary. These feeders shall be of sufficient size to deliver fire flow necessary for the district, shall be frequently spaced and looped; practical dependence of large sections of a city on single mains constitutes a deficiency. Arterial arrangement is divided into fair, poor and very poor. Mains in the arterial system shall be safely installed, the same as supply mains, and shall be so gated that a single failure will not put more than ¼ mile of pipe out of service.

Six-inch is the minimum size pipe which is suited for hydrant supply, and it should be well cross-connected. Experience with 4-inch pipe is such that it is considered a detriment to the system and a charge is accordingly made; the same is true of dead-end 4 and 6-inch pipe. The practice of installing 4-inch pipe cannot be too strongly condemned. During several hundred tests which the speaker has made during recent years, in no case could the hydrant be used to full advantage where connected to 4-inch pipe. The proper sizes for minor distributing pipes depends upon the character of the district served, but they should be well cross-connected and gridironed. Pipe of course should be of good quality,

suited to pressures and well laid. Electrolytic action must be guarded against.

Gate valves are very necessary to localize the effect of a break. The spacing in high value districts should not exceed 600 feet, and in other districts 900 feet. Inspection of all valves yearly and important valves on feeder mains more frequently will insure good condition and will prevent a valve remaining accidentally closed. Records of all valve operations aid proper inspection. A charge is made for lack of inspection or poor condition of valves.

Hydrants should be sufficient in number to supply the required fire flow without the use of long lines of hose. The linear spacing is subject to much variation because of different sized blocks. In the grading schedule, the distribution is worked out on the area served by each hydrant. A table has been made up which gives the standard area to be served per hydrant on the basis of different fire flows required, and for both direct hydrant streams and engine streams. The table is too long to give here but an idea of it may be shown. With direct hydrant streams and 3000 gallons per minute required, one hydrant should be installed for each 70,000 square feet; with engine streams and the same quantity one hydrant for each 100,000 square feet is satisfactory. As the quantity is increased the spacing must be closer. Hydrants should be able to deliver 600 gallons per minute with a loss of not more than 2½ pounds in the hydrant and a total loss of not more than 5 pounds between the street main and the outlet. Two 2½-inch outlets and a large suction connection, where pumping engines are used, are necessary. Street connections and barrel should be 6-inch diameter, with a gate valve on the connection. Hydrants which will remain closed when the barrel is broken off are a necessity with present traffic conditions.

The proper method of setting hydrants varies with the location. Good drainage, solid support for the barrel, ease of repairs and good outlet clearance above the ground are essential. Frequent inspections are needed to maintain hydrants in the best condition. Hydrants are not built for frequent service and use by others than the fire department or inspector should be discouraged, and if necessary special hydrants installed for street sprinklers.

Good records would seem to be a most necessary feature of any water system; to be of value they should include plans of piping at pumping stations and in the distribution system, records of operation, repairs and performance of each part of the water-works. The lack of records, especially in the smaller communities, is astounding.

Use of public water supplies through privately installed automatic sprinkler systems is on the increase. This is not surprising since these systems provide the most effective fire protection yet developed, and give a property so equipped a greatly reduced fire insurance rate. Water superintendents should actively encourage installation of them as they are directly benefitted. Reports on 28,560 fires in buildings so protected show that 20,234 or 84 per cent were extinguished with ten or less sprinkler heads opening, or about 300 gallons per minute maximum. Only about five per cent required more than 1000 gallons per minute. While records are not available there is no question that the same number of fires in similar buildings not so protected would have required many times the same quantity of water, and it costs money to pump water. It is not conceivable for a spreading fire to occur in a district well filled with automatic sprinkler equipments, and the chance of an outside fire entering a sprinklered building is practically eliminated. It seems plain then that the greatest dread of the superintendent, namely a conflagration, would be very remote if buildings were generally protected in this manner. The water used in water curtains from outside sprinklers is large but in few cases would it exceed the quantity used in fire streams to provide the same degree of protection.

The value of a sprinkler system is entirely dependent upon a reliable and adequate water supply. No equipment is standard unless supply can be obtained from two independent sources, generally a tank or pumps installed by the building owner and the public water system. The private supply works are a part of the equipment and are handled directly with the property owner. A public supply, to be satisfactory as the primary source, must be able to maintain 12 pounds pressure on the top line of sprinklers while 500 gallons per minute are flowing from the nearest street hydrant. If the public supply is to be used as the primary source the pipe connection must be large enough to pass sufficient water for all heads on the largest floor or area. No pipe smaller than 6-inch is of value and in many cases larger pipe is needed. The possibility of pollution to domestic supply is recognized and double check valves of special design are not considered detrimental. Many superintendents fear misuse of such connections; friendly coöperation with owners will generally prevent this, but special meters can be purchased suitable for the service. The charges made for

such a connection vary greatly. Many cities show a tendency toward basing charges upon the insurance benefit the property derives from this service and this is not considered just. The owner simply does the work which the fire department would otherwise perform, and in a much more effective manner, and should not be penalized for it. Charges which cover installation, maintenance and carrying charges are warranted and there is seldom objection to them.

In conclusion, any effort which will help to check and reduce the senseless fire waste in this country is justified. The saving of a few dollars by omitting needed repairs, an extra pump or added supply, by laying smaller pipe than required, or failing to keep all parts of the system in good condition may result in a disaster in your community, far outweighing the saving. Make your efforts toward providing reliable fire protection commensurate with the importance it deserves and your city will enjoy more freedom from fire losses, which means lower insurance rates.

USE OF PORTABLE AIR COMPRESSOR ON WATER WORKS DISTRIBUTION SYSTEM[1]

By F. C. Amsbary[2]

I confess to being somewhat embarrassed in appearing before you this morning for the reason that I am so poorly equipped to talk upon the subject assigned to me. Mr. Gwinn sometime ago wrote asking me to write on some subject. I was somewhat at a loss to find a subject that I thought might be interesting, but as we had placed an order for a portable air compressor to be used in our distribution system in various ways, I sent that subject in to him, believing that I would have sufficient time to gather some reliable data, but they were slow in delivering this machine and I only had it in actual use about a week before I left Champaign for this convention. In that time we finished a few jobs and I can give you the figures on them.

Our plant is a rather small one having about 95 miles in the distribution system and 7000 active services. We have in our city perhaps 30 miles of concrete pavement and brick laid on concrete, and in case of leaks and extension connections, as you all know, it is frequently necessary to go through the concrete. Our plant is not large enough to justify the expenditure of a sum sufficient to buy an air compressor for our own exclusive use, so we talked with some of the contractors there and were assured that they would give that machine considerable use by rental, so we went into the proposition. We bought an air compressor mounted on a Ford truck so arranged that by throwing a lever it would engage the air compressor. This outfit would be a considerable advantage over the kind of a compressor we would have to haul around from job to job. I think that is going to work out all right. We took one job from a contractor who was putting in an ornamental lighting system. I had him keep a record of just what it was costing him to take out

[1] Presented before the Superintendent's Session, Detroit Convention, May 25, 1923.

[2] Manager, Water Company, Champaign, Ill.

the curb and gutter along the street in the business district where he was going to lay his conduits, and in this one case he had a stretch of 121 feet and it cost him 22 cents a lineal foot to remove the curb and gutter. On the opposite side of the street we took out exactly the same amount of concrete and we did it for 9½ cents per lineal foot. Charging him at this rate we fixed this price after careful figuring, taking into account interest on invested capital, depreciation and repairs. We had a case where we took out for our own use on our own work a stretch of 21 feet long by 2 feet wide of very hard concrete, which we did in twenty minutes, while on the best record we had on that sort of work it would take two men two hours each. As I said in the beginning, I am sorry that I have not been able to give you more data, but I am quite certain it is going to pay us to have that machine and the revenue that we will receive from contractors will, I think, in time make it a very good investment.

The cost of this machine, the compressor and tools, was $1087.31; the truck cost $557.88. The expense to bring it from the place where it was purchased to our town was $44.50 making a total, investment of $1723.

I might say that there are other uses to which we intend to put this machine. For instance, we have bought a pneumatic spade, and I think we will get splendid use from the spade; it will take the place of picks. It is worked on the same principle as the concrete breaking device, it just spades up the earth where it is very hard and turns it over, and then it is shovelled out; it simply takes the place of a pick but does the work much more rapidly.

SAFEGUARDING HOT WATER INSTALLATIONS[1]

By Chetwood Smith[2]

A better title would perhaps have been the necessity of safeguarding hot water installations.

With the exception of the first range boiler explosion, all the photographs appearing herein were either taken by or for the Stack Heater Company. The tests shown were made on actual installations and in no sense could be called laboratory tests.

The interesting feature of the first explosion shown in figure 1[3] is that the entire corner of the house was blown out and as far as our records go we know of no other explosion in which this took place.

The tubes of gas water heater used in these tests were of copper of five sixteenths outside diameter, 18 gauge, which gives a ration of heating surface to area of 20 to 1.

A $\frac{3}{4}$ inch coil gas water heater which has a ratio of only 6 to 1 heating surface to area would of course require a longer time for explosion, but would produce exactly the same results.

The most interesting feature of the explosion shown in figure 2 is the resultant location of the boiler stuck in the ceiling between the top floor and the roof and what is most interesting about this special photograph is that although it is copyrighted, a competitor borrowed if for his advertising without permission. Perhaps he made a mistake.

Boiler explosions do not care whether they have shingle houses, business blocks or concrete homes for their work and they always proceed in the same thorough manner. In an explosion in a business block the relief valve was afterwards found. This was tested by the State Inspector in our factory and failed to operate until the pressure was raised to 640 pounds.

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] President and General Manager, The Stack Heater Company, Boston, Mass.

[3] All photographs copyrighted by Stack Heater Company.

In another explosion the houses were too near together to get a good photograph of the outside of the house. The interesting feature of this explosion is that the boiler must have rocketed two hundred yards above the house as it was exactly 112 yards down the street when it landed. When the super heated steam in this boiler had used up its energy a partial vacuum must have been formed which collapsed the sides of the boiler.

FIG. 1

A wallet was on the kitchen table within 5 feet of the boiler in a Watertown explosion. All the papers and bills were taken out and forced against the lathes on a side wall where they stuck. The wallet was left on the table. A bird cage with a canary in it was left hanging in the window. All the seeds and water were blown out, but the bird was unharmed.

In the Boston University explosion, 1200 students were close to this boiler 15 minutes before the explosion. The boiler must have split its entire length and traveled as a vertical plane before it struck a brick wall 40 feet distant, as the entire shell of the boiler bore the

imprints of the bricks. The market price of the relief valve used to safeguard 1200 students was eighty five cents.

Fig. 2

The energy developed by such explosions is indicated in the figures tabulated in table 1. These figures are not the result of actual tests made by us, but were compiled by Professor Miller of the Boston Polytechnic Institute.

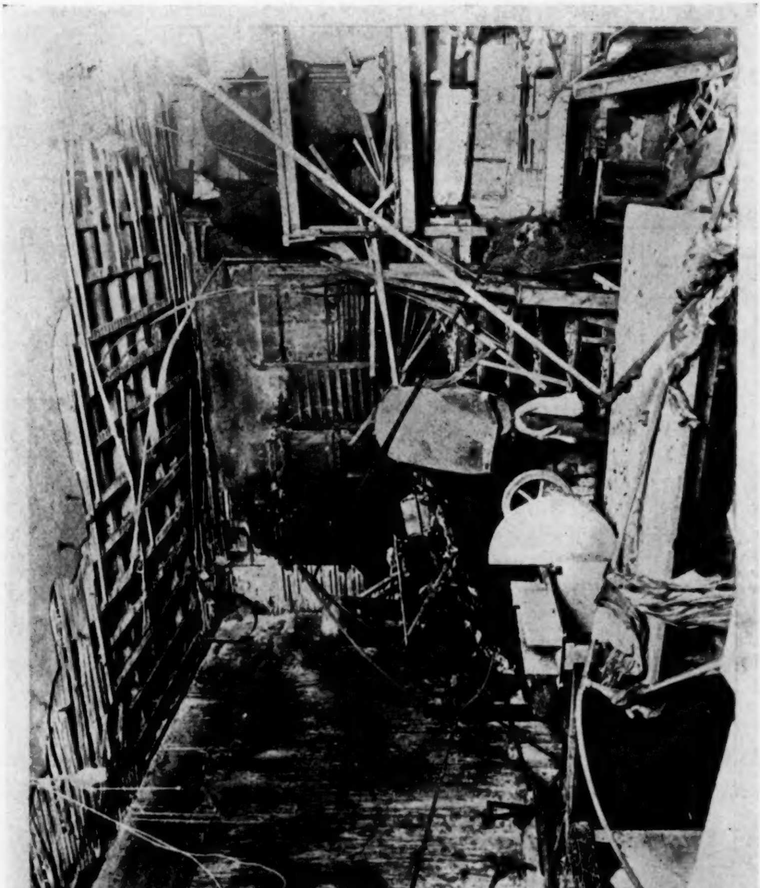


FIG. 3

A safe relief valve should have the water constantly passing through it to prove that the boiler pressure has access to the valve. It should preferably be of a diaphragm type.

These are requirements as laid out by the Boiler Code Committee of the American Society of Mechanical Engineers. There is no valve at present on the market which meets all these requirements, but there will be very soon as one was yesterday submitted to and approved by the Chief Inspector for the State of Michigan.

TABLE 1

Energy developed by explosion of 30 gallon tank of hot water under varying temperatures and pressures

PRESSURE			TEMPERATURE AT BOILING	WEIGHT OF CUBIC FOOT WATER	WEIGHT IN 30 GALLONS	PER CENT FLASHING INTO STEAM	WEIGHT FLASHING INTO STEAM	VOLUME OF STEAM	FOOT POUNDS ENERGY LET LOOSE
Absolute	Gage	Feet of water							
14.7	0		212.0						
24.7	10	23.1	239.5	59.06	237	2.81	6.66	178	479,800
34.7	20	46.2	259.0	58.52	235	4.75	11.1	298	914,100
44.7	30	69.2	274.0	58.20	233	6.21	14.5	378	1,305,000
54.7	40	92.3	286.6	57.59	231	7.41	16.4	440	1,689,300
64.7	50	115.4	297.7	57.26	230	8.46	19.5	521	2,021,900
74.7	60	138.4	307.4	56.93	228	9.36	21.4	570	2,341,200
84.7	70	161.7	316.0	56.66	227	10.1	22.9	614	2,642,000
94.7	80	184.6	324.0	56.36	226	10.9	24.6	660	2,900,000
104.7	90	207.7	331.2	56.23	225	11.5	26.1	700	3,138,400

A comparison with powder may be interesting:

One lb. black powder gives........................ 960,000 ft. lbs.
One lb. smokeless powder gives....................1,260,000 ft. lbs.
One lb. nitroglycerine gives......................2,000,000 ft. lbs.

THE EFFECT OF INDUSTRIAL USES OF WATER ON TOTAL CONSUMPTION[1]

By J. Walter Ackerman[2]

The above title would indicate a comprehensive research, but the reverse is the actual fact in this case, because only enough is intended to be given to induce others who are more capable to discuss the subject from any standpoint that they desire.

The writer took charge of the water works in Watertown in June, 1920, and immediately started the installation of meters, and later had a Pitometer survey made. This brought down the consumption from an abnormal one to a reasonably normal rate per capita. It will be noted from figure 1 that the consumption rate began again to climb up. This reaction was to be expected to a certain extent but as it continued for a longer period than anticipated, an analysis was made of the different classes of use to see if some reason could not be found for the rising rate per capita.

This consisted in tabulating the metered consumers for the different classes of use that were not domestic. The analysis of what is covered under the title of industrial, actually includes not only all of the industrial use, such as factories, railroads, etc., but also the large consumption of business blocks and office buildings.

It is later seen from figure 2 that the domestic use, after dropping from the high rates of 1918 and 1919, has actually remained nearly stationary after the installation of the meters, which covers something over 50 per cent of the total number of services in the city.

The conclusion to be arrived at in this case, if a conclusion may be deduced from this small analysis, is that increasing per capita rates should be investigated from a somewhat similar angle, in order to determine whether or not increasing activities in the city do not adequately explain the increasing per capita rate. Instead of looking immediately for other reasons, it is well to examine the industrial uses first.

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] City Manager, Watertown, N. Y.

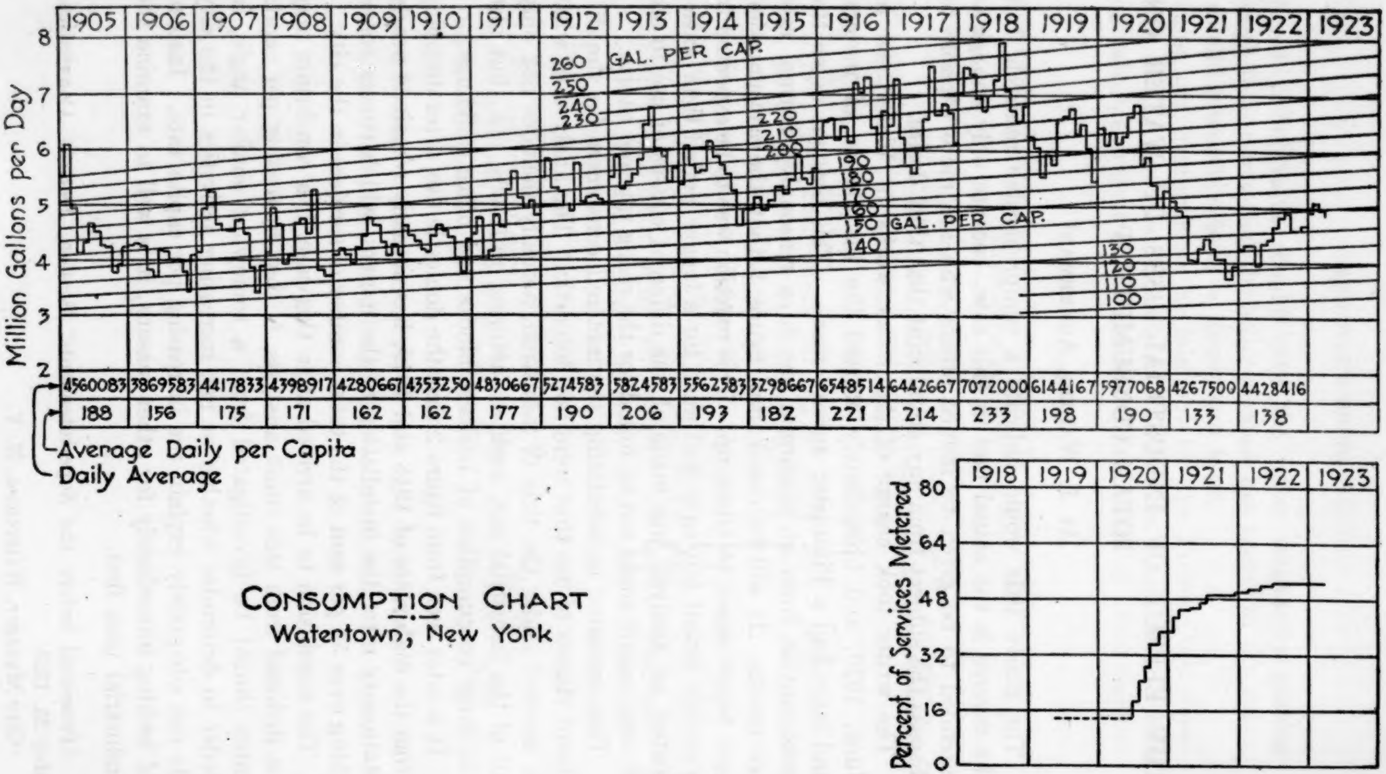

CONSUMPTION CHART
Watertown, New York
Million Gallons per Day
Average Daily per Capita
Daily Average
GAL. PER CAP.
Percent of Services Metered
1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923
4560083 3869583 4417833 4398917 4280667 4353250 4830667 5274583 5824583 5562583 5298667 6548514 6442667 7072000 6144167 5977068 4267500 4428416
188 156 175 171 162 162 177 190 206 193 182 221 214 233 198 190 133 138

FIG. 1

In connection with this it might well be pointed out that the financial side of the water works might be seriously handicapped by a large rise in industrial use of water, which usually is sold at the lowest rate of all. In some cases unfortunately this rate does

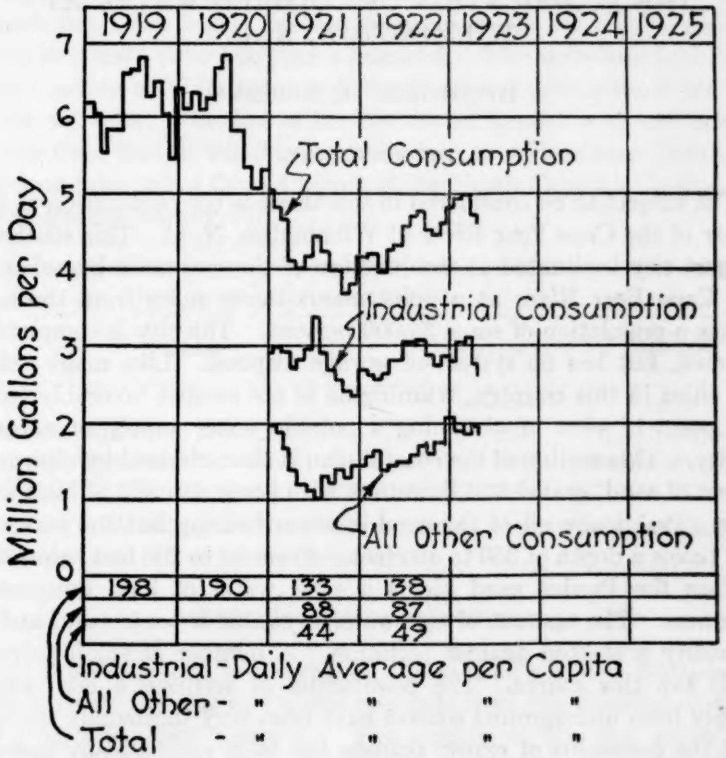


FIG. 2

not represent the actual cost of the water supplied. Consequently a water works might find itself very seriously handicapped, if industrial consumption mounted to a high figure in proportion to that of other uses.

THE PURIFICATION OF COLORED WATER AT WILMINGTON, N. C.[1]

By George D. Norcom[2]

INTRODUCTORY

The subject to be considered in this thesis is the purification of the water of the Cape Fear River at Wilmington, N. C. This southern seaport city is situated at the junction of the two main branches of the Cape Fear River at a point about thirty miles from the sea. It has a population of some 35,000 persons. The city is completely sewered, but has no system of sewage disposal. Like many other old cities in this country, Wilmington is not located favorably from the point of view of obtaining a potable water supply of natural purity. This section of the coastal plan is characterized by alternate layers of sand, gravel and limestone with some deposits of mud and clay. Practically all of the sand is water bearing but the water is salt below a depth of 350 to 400 feet. From 60 to 200 feet below the surface the Peedee sand yields a clear water of high temporary hardness. The amount of this water available is conjectural and it is poorly protected against pollution. A number of small private wells tap this source. The possibilities of securing a city water supply from underground sources have been very thoroughly studied and the consensus of expert opinion has been emphatically against such a project (1), (2), (3). In view of these facts Wilmington was forced to turn to the river to secure a public water supply.

THE CAPE FEAR RIVER

At Wilmington, the Cape Fear River divides into the Northeast and Northwest branches. The Northeast Branch has a flat grade and drains a vast area of swamp land so that the run off of the stream is very largely composed of swamp water. This water is charac-

[1] Abstract of thesis presented to Rutgers College in partial fulfillment of requirements for degree of Sanitary Engineer.

[2] Health Department, Wilmington, N. C.

terized by a high color the result of the action of soft water on the organic matter of the swamp. This water is practically free from turbidity but has an average color of 150 (Platinum-Cobalt Scale). The Northwest Branch drains an area which is more hilly and rolling and is largely under cultivation. While the Northwest Branch has some highly colored tributaries, its water is normally turbid and has a color less than a hundred. Where the two branches come together at Wilmington a distinct line of demarkation is visible on the ebb tide. The flow of the Northwest Branch is several times greater than that of the Northeast Branch as will be seen from the following table taken from a report of the North Carolina Geological and Economic Survey (4).

Daily discharge of drainage areas above Wilmington (unit discharge 1.17 sec. feet per square mile)

STREAM	DRAINAGE AREA	AVERAGE ANNUAL DISCHARGE PER DAY
	square miles	*gallons*
Northeast Cape Fear	1570	1,186,000,000
Northwest Cape Fear	7005	5,295,000,000

There is a tidal change in the river four times each twenty-four hours with a rise and fall of about three feet.

SOURCE OF THE WATER SUPPLY

The present intake is located on the east side of the Northeast Branch above the city and about one mile from the junction of the two branches. (See figure 1.) The quality of the raw water is subject to frequent changes, the factors causing the changes being chiefly: (*a*) variation in the tides; (*b*) relative amounts of rainfall on the watersheds of the two branches of the river which affect their stages; and (*c*) the amount of sewage from the city which reaches the intake. The third factor is influenced by the first two, since the discharge of sewage per twenty-four hours is fairly constant. Normally, the water reaching the plant at low tide is the highly colored Northeast Branch water, while at high tide it frequently contains a large proportion of the turbid Northwest Branch water. During the ebb and flow of the tide varying mixtures of the two are encountered in which either type may predominate. For this reason, the raw water at Wilmington is one of the most difficult to purify which

may be found in the United States. These conditions are sometimes complicated by sea water reaching the intake.

The sewage from the main part of the city is discharged at various points along the water front. The sewage from a large part of the eastern section of the city formerly discharged into Smith's Creek, a small stream, which enters the Northeast Branch at a point about 1500 feet above the water intake. This sewage is now collected by an interceptor and pumped to the main river which it enters about one-half mile below the intake. However, great difficulty is experienced in operating these pumps and at frequent intervals the sewage

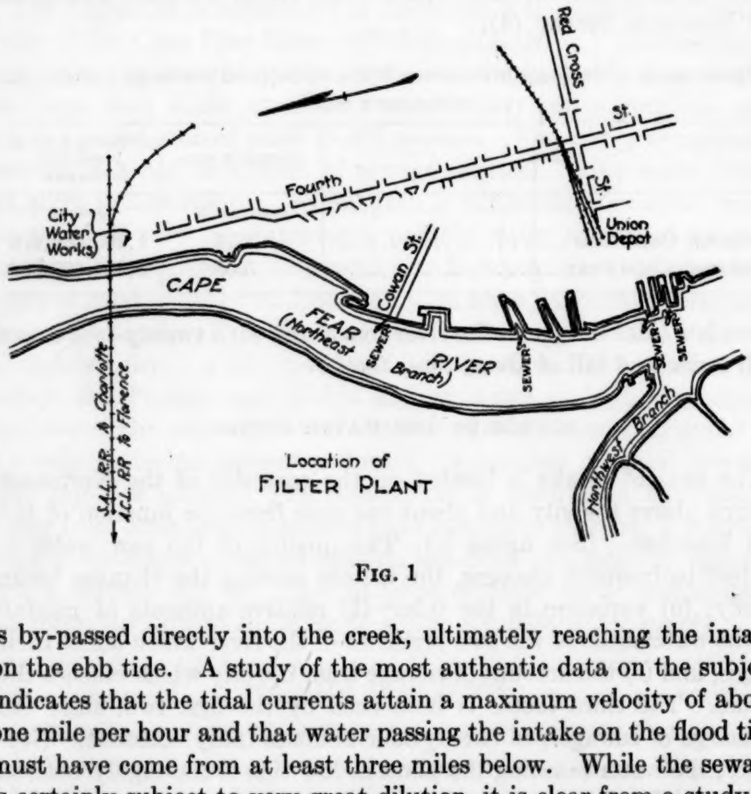


FIG. 1

is by-passed directly into the creek, ultimately reaching the intake on the ebb tide. A study of the most authentic data on the subject indicates that the tidal currents attain a maximum velocity of about one mile per hour and that water passing the intake on the flood tide must have come from at least three miles below. While the sewage is certainly subject to very great dilution, it is clear from a study of the analytical data that the raw water is at times highly polluted. It is to be borne in mind that this pollution is very fresh and therefore much more virulent, and that the bacterial evidence of pollution in such a stream has a much greater significance than it has in a stream

which has a greater period for self purification. In the light of recent advances in the art of water purification, it appears that the pollution of the raw water is in excess of standards for the loading of filtration plants. In 1914 the International Joint Commission fixed a standard for raw waters which provided, in substance, that the average load upon any water filtration plant should be such that the raw water delivered to it should not contain more than 500 B. coli per 100 cc. The reasonableness of this standard was later confirmed by Streeter in his studies of filter plant loading (5).

THE PURIFICATION PLANT

Historical

The first city water supply for Wilmington was furnished by the Clarendon Water Company which established a pumping station on the site of the present purification plant in 1881. At this time no attempt was made to purify the water. The unsightly appearance of the water and the prevalence of typhoid fever led to the establishment of a filtration plant in 1906. The preliminary studies in connection with adoption of filtration were made by George C. Whipple of Hazen, Whipple and Fuller (6). Briefly, he recommended the process known as mechanical filtration using alum as a coagulant. The first plant was built by the Pittsburgh Filter Co. and consisted of a sedimentation basin of 360,000 gallons capacity, four filters of 500,000 gallons each, a clear well of 160,000 gallons capacity and the accessory pumps, chemical tanks, etc. By referring to figure 2 the relative position of these first units may be readily seen; the basin is marked no. 2 and the filters 1, 2, 3, 4. This plant was operated by the engineer of the pumping station and while no operating data are available we may judge that results were not entirely satisfactory, since in 1911 the City again called Mr. Whipple. In a report (7) dated December 7, 1911, Mr. Whipple showed that the plant could be successfuly operated and recommended that a trained man be put in charge of the filters. In 1912, this recommendation was carried out.

As the consumption of water increased it became necessary to enlarge the plant. The first addition was made in 1911 under the supervision of Hazelhurst and Anderson, Consulting Engineers. This addition consisted of a new basin of 360,000 gallons capacity (no. 3 on figure 2) and filters installed by the American Water

Softeners Co. (nos. 5, 6, 7, and 8). The proposed plan of operation called for the two basins to be used in parallel, each being

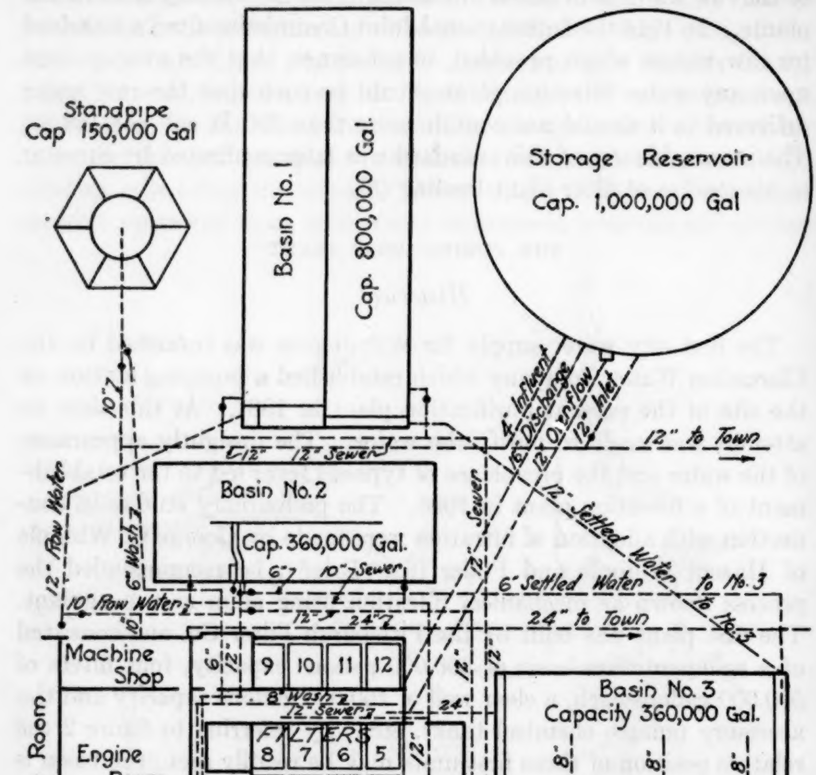


Fig. 2

supplied by a separate raw water pump. This scheme did not work successfully for several reasons; (a) chemicals had to be applied to

two points from one set of dosing apparatus, (*b*) it was impossible to give the water a double treatment of chemicals, the necessity for which will appear later. The last addition to the plant was made in 1918 and consisted of a new settling basin of 800,000 gallons capacity (no. 1 on figure 2) and four new filters (nos. 10, 11 and 12).

THE RAW WATER

The nature of color in water

The exact nature of color in water has never been determined. It has been the custom to state that the coloring matter was composed largely of organic substances in solution of the nature of tannic acid, humic acid, the tannates, gallates, glucosides, etc. The coloring matter is certainly of an organic nature, since it can be readily destroyed by ignition of the total solids. High color in water is generally accompanied by a high iron content. The average of a number of determinations of iron on the Cape Fear water show it to be in excess of 1 p.p.m. Some writers (9) believe that the coloring matter in water is intimately associated and possibly in combination with the alkalinity. Our views on the nature of color in water have been considerably clarified by the work of Saville (10). This investigator has shown by a very interesting series of experiments "that color in water is certainly in the colloidal state and that it exhibits definite characteristic electrical properties which substantiate this contention." Moreover, Saville states that experiments made in the Laboratory of Hygiene and Sanitation at Harvard University indicate that color in water behaves as a colloid when subjected to dialysis and to examination in the ultra microscope. To quote from Saville's conclusions,

> Color in water in large part exists in the form of colloidal suspensions of ultramicroscopic particles. Some of the color may be due to colloidal emulsoids. A small part of the color is probably due to non colloidal material, organic acids, and neutral salts in true solution. The colloidal coloring matter, whether suspensoids or emulsoids, carries an electrostatic charge. This charge may be positive or negative depending on the character and source of the water and varying in different waters. Color in water is usually due to negatively charged colloidal material. . . . . Since these particles carry an electric charge and are in colloidal suspension, they obey the laws of cataphoresis when an electric current is sent through a colored water. The particles are attracted to the electrode of opposite sign from the charge which they carry. They are discharged, flocculate, and precipitate, with consequent reduction in the color of the water.

The theory outlined above explains very satisfactorily the phenomena observed at the Wilmington plant. Experiments by G. F. Catlett and the writer tend to show that the coloring matter in the raw water is largely due to colloidal matter, which for the greater part of time at least is negatively charged.

Physical characteristics

As has been stated the raw water is always highly colored and frequently turbid. Normally the water has a perceptible vegetable odor. The following table gives an idea of the variation in color and turbidity.

YEAR	COLOR			TURBIDITY		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	133	350	20	94	650	10
1921	161	260	40	48	200	0
1922	160	300	70	33	410	0
	151	350	20	58	650	0

Chemical characteristics

As has been stated the physical quality of the water is subject to wide fluctuation but chemically there is very little variation, except in case of sea water contamination which is fortunately of rare occurrence. The following results of analysis indicate the general type of water.

Sanitary

George C. Whipple Report December 7, 1911

Sample taken November 12, 1911

	p.p.m.
Alkalinity	14.0
Chlorine	8.0
Oxygen consumed	16.9
Nitrogen as nitrate	0.070
Nitrogen as nitrite	0.000
Nitrogen as free ammonia	0.026
Nitrogen as albuminoid ammonia	0.270
Total residue	107.00
Loss on ignition	40.00
Fixed residue	67.00

Industrial

(Average of weekly determinations for one year United States Geological Survey 1906–1907).

Total iron (Fe)	1.3
Silica (SiO_2)	9.9
Calcium (Ca)	5.0
Magnesium (Mg)	1.5
Sodium and potassium (Na&K)	7.2
Carbonate radicle (CO_3)	0.0
Bicarbonate radicle (HCO_3)	25.0
Sulphate radicle (SO_4)	3.2
Nitrate radicle (NO_3)	0.2
Chlorine (Cl)	5.8
Total dissolved solids	57.0

The following is a summary of the results of daily routine tests for the past three years.

YEAR	ALKALINITY			CHLORINE		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	8	15	4	21	320	5
1921	11	21	6	155	3,265	4
1922	10	18	4	15	380	3
	10	21	4	64	3,265	3
	FREE CO_2			TOTAL HARDNESS		
1920	8	15	2	21	34	12
1921	8	15	2	37	326	10
1922	6	14	2	8	17	0
	7	15	2	22	326	0

Bacteriological characteristics

Bacteriologically the quality of the water is subject to great variation as has been explained under "Source of supply." The following summary taken from the annual reports will serve to show this.

Results of daily bacteriological tests on the raw water

YEAR	TOTAL BACTERIA PER CUBIC CENTIMETER AT 20°C.			TOTAL BACTERIA PER CUBIC CENTIMETER AT 37°C.			B. COLI PER 100 CC. AVERAGE
	Average	Maximum	Minimum	Average	Maximum	Minimum	
1920				999	6,500	50	530
1921	2,972	36,000	50	3,085	30,000	75	3255
1922	1,781	27,000	170	1,333	20,000	100	2712
	2,376	36,000	50	1,806	30,000	50	2166

The following table has been prepared to show the seasonal variations in the number of bacteria in the raw water. Monthly averages of daily counts at 20°C. and 37°C. together with B. coli tests are shown. These data indicate that the 37° bacteria and B. coli increase from a minimum in the winter months to a maximum in the summer. The 20° count is higher than the 37° count in winter and lower in summer. This tends to prove that the death rate of body temperature organisms in the Cape Fear Water is lower in summer than in winter. Doubtless the dry weather usually experienced in the fall tends to cause a maximum at that time.

Comparative bacterial counts on gelatine at 20°C. agar at 37°C and B. coli per cubic centimeter on the raw water

MONTH	BACTERIA PER CUBIC CENTIMETER		B. COLI PER CUBIC CENTIMETER
	20°C.	37°C.	
1921			
January	639	496	
February	445	332	
March	715	460	
April	4,475	1,443	
May	2,916	1,757	23.80
June	3,502	3,057	43.20
July	3,912	4,488	38.30
August	3,507	5,495	38.30
September	3,055	5,992	42.50
October	6,945	9,030	60.10
November	3,807	3,173	73.30
December	1,739	1,298	46.20
1922			
January	1,610	873	25.60
February	1,766	561	10.60
March	1,545	255	18.70
April	1,883	653	26.00
May	1,292	818	36.10
June	1,764	2,337	37.60
July	1,147	2,009	37.40
August	1,524	1,940	27.30
September	723	833	25.80
October	1,023	1,117	32.50
November	1,232	1,092	22.20
December	5,860	3,510	25.80

Coagulation and decolorization of the raw water

At Wilmington coagulation of the water is brought about by the addition of sulphate of alumina and lime. The general principle of the reaction is summarized by Saville (10) as follows:

It may be said that, when most successfully used, the action depends upon the discharge of a negative color colloid by the positively charged ion of the coagulating agent and the positively charged hydroxide which is formed. The consequent neutralization of the charged color colloids results in flocculation, precipitation and decolorization. This process is materially aided by the mechanical removal of the color colloids by the hydroxide floc which is formed. When clarification is obtained with difficulty, the reason is frequent that the color colloids in the water bear a positive charge. Hence they are not discharged by the positive ion of the dissociating coagulant. Under such conditions the removal of color is supposed to be entirely a mechanical process resulting from enmeshment and straining out of the color colloids by the precipitated hydroxide floc.

Some observers claim that when a highly colored water and a turbid water come together mutual precipitation of the colloids take place with resulting clarification of the water. Since both color and clay turbidity normally bear a negative charge it is hard to see how such a view can be maintained. On the contrary when the colored Northeast Branch mixes with the turbid Northwest Branch of the Cape Fear the resulting mixture retains both color and turbidity and is much harder to clarify with sulphate of alumina than either water alone.

Given a well designed filter plant, success or failure in the purification of a highly colored water rests almost entirely on the basin treatment. In treating waters of this type the practice has tended toward a longer period of contact and a somewhat higher velocity than is customary in treating turbid waters. However, experience at Wilmington has taught that regardless of the retention time, velocity or mixing, it is impossible to secure decolorization unless the amounts of chemicals applied are very carefully balanced. The amount of alkalinity necessary to react with one grain per gallon filter alum is usually given as 7.7 p.p.m. ($CaCO_3$). In a recent paper Mr. R. S. Weston (11) makes the following statement:

At present sulphate of alumina is added until coagulation takes place, and, in most cases, soda is added to maintain an alkalinity of at least 7 p.p.m. in the water delivered to the mains.

Catlett (12) has explained how the system of adding all the alum and alkali to the water before sedimentation failed at Wilmington. After many trials he adopted the practice of adding only a portion of the alkali with the alum and after coagulation and partial sedimentation had taken place, of adding a secondary dose of alkali to furnish a final alkalinity of 10 p.p.m. Greatly improved results were secured. Further study of this subject has led to the conclusion that best results are obtained in the first basin by allowing an amount of alkali equivalent to 4 p.p.m. ($CaCO_3$) for each grain per gallon of alum. The amount of alkali required in addition to the natural alkalinity is added with the alum in the pump suction in the form of calcium hydroxide. For plant control the alkalinity furnished by commercial hydrated lime, 70 to 75 per cent $Ca(OH)_2$, may be considered equivalent to $CaCO_3$ as will be seen from the following equation. Assuming 74 per cent $Ca(OH)_2$:

$$\text{p.p.m. hydrated lime} \times \frac{74}{100} \times \frac{CaCO_3}{Ca(OH)_2} = \text{p.p.m. } CaCO_3$$

The secondary dose to bring up alkalinity is usually added in the last basin but may be added to the clear well.

Let us now focus our attention on some of the results obtained by the application of hydrogen ion determinations to water purification. Work by Wolman and Hannan (14), Bayliss (15), and Hatfield (16), as well as many others have led to the conclusion that there is an optimum pH valve around which good coagulation results may be expected and that, if the pH varies much from the optimum, very little or no floc may be expected. The location of this optimum point seems to be about 7.0 on the waters reported thus far. The writer believes that this point varies with different waters and that it may be anywhere on the pH scale from 4.4 to 7.6. Theriault and Clark (13) have developed titration curves for alkali and alum and have carried out a very interesting series of experiments where pH was plotted against time required for the formation of visible floc. They have demonstrated that the optimum (iso-electric) point for the precipitation of aluminum in pure and buffered solutions is very close to pH 5.5. They conclude that, "The hydrogen ion concentration of the final mixture of water and alum is of fundamental importance in the formation of floc."

In actual practice we are not dealing with pure or carefully buffered solutions. The raw water contains small quantities of a great

number of substances in solution. In the case of a highly colored water there is a relatively large amount of colloidal coloring matter. It is possible that this coloring matter has an optimum pH at which it is precipitated, although the writer has not succeeded in discovering any evidence of this fact. It is more certain that there is a very definite optimum pH for the coagulation of alum-color mixtures in water. While the optimum point for the precipitation of $Al(OH)_3$ is doubtless 5.5, it seems probable that there is likewise a definite optimum pH for the precipitation of alum and color. The precipitate in this case is undoubtedly very complex, but we may represent it as a mixture of (Al^+ $Color^-$) and (Al^+ $(OH)_3$ $Color^-$).

It has been the custom at this plant to determine the dose of chemicals by floc tests in jars. A number of clean glass jars are filled with one liter of water each, and various amounts of alum and lime solutions are added to each. The dose in the jar showing best decolorization in the shortest time with a minimum of chemicals is selected for application to the plant. Invariably the decolorized water in this jar shows a pH very near 4.4 and the ratio parts per million alkalinity to one grain per gallon of alum will be found very close to 4:1. Similar tests on the treated water after practically all the color has been removed show an optimum pH between 5.4 and 5.6 which demonstrates that the color present was responsible for the lower optimum pH obtained on the raw water. The writer has prepared three curves to demonstrate the relations involved. It should be stated that there is always a minimum value of alum below which complete decolorization cannot be obtained. This is to be expected since there must be at least sufficient alum present to completely react with the color if complete precipitation is to be attained. For this reason no values have been plotted for experiments where the dose of alum was too low to secure complete reaction. As may be expected, some of the values do not fall on the curve and this is not surprising, since, by the method used, the observer was required to carry in mind a picture of the condition represented as "excellent," "good," etc. This is a very poor method at best, for a floc might have been classified as "excellent" on one day and a floc of exactly the same quality might have been classified as "good" on another day. It is fully realized that a comparison between pH and the amount of alum remaining in solution would have been much better, but this investigation must await the perfecting of an analytical method for the determination of small amounts of aluminum. How-

ever, the general trend of the curve is unmistakable. The variations in the experiments are shown below:

August 7, 1922. Alum constant, amount of alkalinity varied.
August 8, 1922. Alum constant, amount of alkalinity varied.
August 24, 1922. Alum constant, amount of alkalinity varied.
November 11, 1922. Alum constant, amount of alkalinity constant.
November 11, 1922. Alum constant, amount of alkalinity constant.
November 11, 1922. Alum constant, amount of alkalinity varied.
February 17, 1923. Alum varied, amount of alkalinity constant.

In figure 3 is shown the degree of clarification plotted against pH. The region for the formation of an excellent floc is very narrow, pH

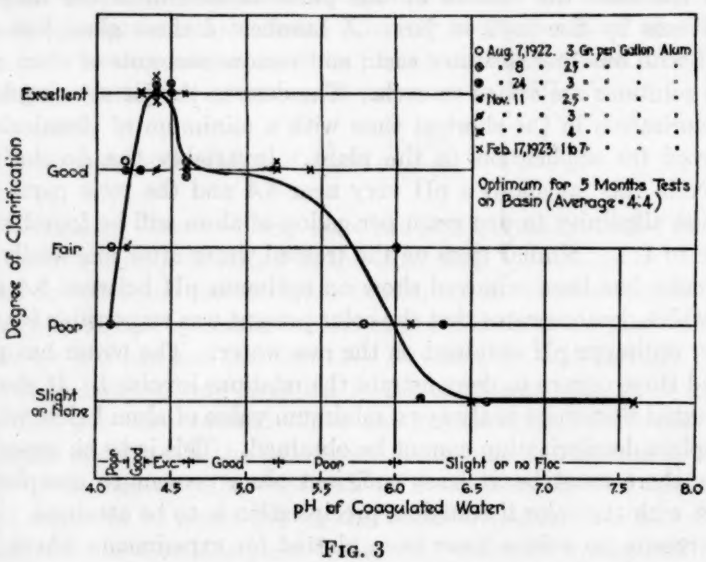
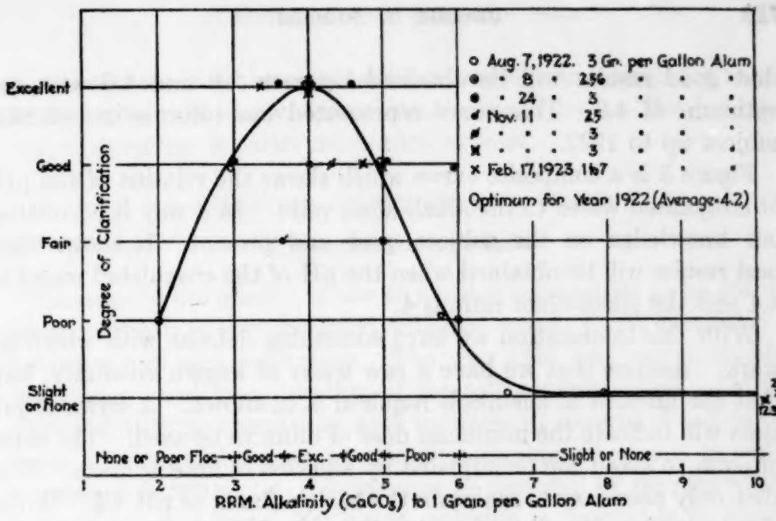


FIG. 3

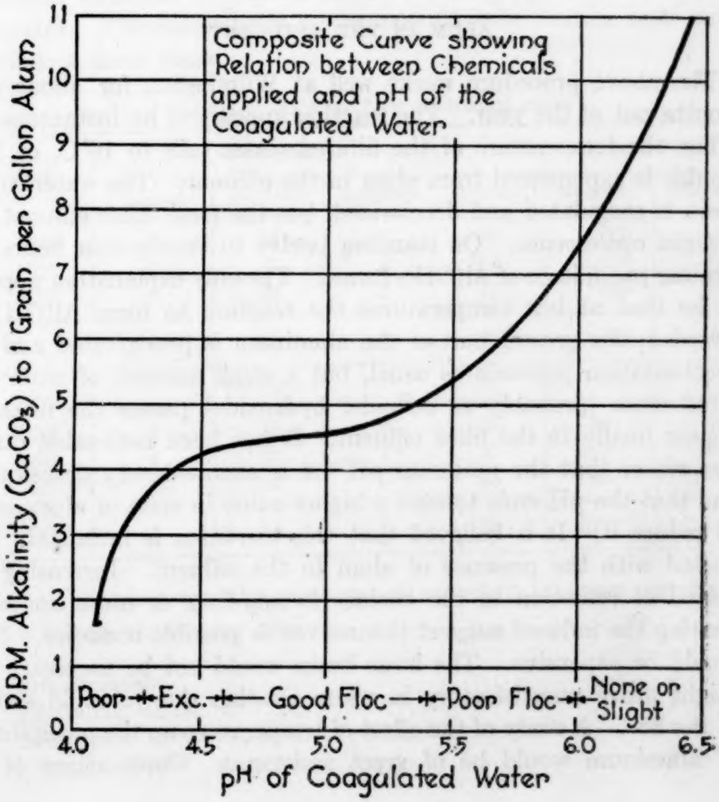
4.3 to 4.6. A good floc may be expected between pH 4.2 and 5.2. Outside these limits poor results will be obtained. In this connection the following quotation from Theriault and Clark (13) is of interest, "We would expect that a water of low alkalinity or low total salt content should require a much more delicate adjustment of the dose of alum than a water of high alkalinity or high salt content."

In figure 4 degree of clarification is plotted against the ratio of parts per million alkalinity to one grain per gallon alum. In general this curve is similar to that of figure 3 but does not show quite as narrow a range for the production of an excellent floc. It indicates



Excellent
Good
Fair
Poor
Slight or None
Degree of Clarification
o Aug. 7, 1922. 3 Gr. per Gallon Alum
Optimum for Year 1922 (Average 4.2)
None or Poor Floc
Good
Exc.
Good
Poor
Slight or None
P.P.M. Alkalinity ($CaCO_3$) to 1 Grain per Gallon Alum

FIG. 4



Composite Curve showing Relation between Chemicals applied and pH of the Coagulated Water
P.P.M. Alkalinity ($CaCO_3$) to 1 Grain per Gallon Alum
Poor
Exc.
Good Floc
Poor Floc
None or Slight
pH of Coagulated Water

FIG. 5

that good results will be obtained between 3.0 and 5.0 with an optimum of 4.0. This curve represented our information on the subject up to 1922.

Figure 5 is a composite curve which shows the relation of the pH of coagulated water to the alkali-alum ratio. In a way it correlates our knowledge on the subject, past and present. It shows that best results will be obtained when the pH of the coagulated water is 4.4 and the alkali-alum ratio is 4.

With this information we have something definite with which to work. Assume that we have a raw water of known alkalinity, but that the amount of chemicals required is unknown. A series of jar tests will indicate the minimum dose of alum to be used. The ratio of alum to alkali can be adjusted by addition of lime hydrate. It is then only necessary to maintain the basin effluent at pH 4.4. While this looks easy it will be found sufficiently difficult in practice.

ALUM IN THE EFFLUENT

The above procedure works well at Wilmington for about nine months out of the year. The reaction appears to be instantaneous. When the temperature of the filtered water falls to 10°C. or less, trouble is experienced from alum in the effluent. The water in the basin is coagulated and decolorized, but the fresh filter effluent has a slight opalescence. On standing twelve to twenty-four hours the familiar precipitate of $Al(OH)_3$ forms. The only explanation appears to be that at low temperatures the reaction to form $Al(OH)_3$ is retarded; the greater part of the aluminum is precipitated and the decolorization proceeds as usual, but a small amount of unprecipitated alum (probably as colloidal hydroxide) passes the filters to appear finally in the filter effluent. It has been noticeable during the winter that the optimum pH 4.4 is attained only occasionally and that the pH ends toward a higher value in spite of every effort to reduce it. It is believed that this condition is intimately connected with the presence of alum in the effluent. Increasing the period of retention in the basins (twenty-four or more hours) or heating the influent suggest themselves as possible remedies. Both would be expensive. The large basin would not be necessary and might prove unsatisfactory in warm weather due to rapid settling of the floc. A study of the effect of temperature on the precipitation of aluminum would be of great assistance. Observations of the

filters indicate that there is less likelihood of alum passing a newly washed filter than one with considerable loss of head. This indicates that the problem is partly mechanical at least.

CHARACTER OF THE TREATED WATER

Chemical characteristics

Chemically the quality of the city water leaves little to be desired except when it is contaminated with sea water, which condition is fortunately of rare occurrence. The year 1921 was exceptional for the amount and long duration of the salt contamination. During 1920 and 1922 no complaints were received on account of salt in the water. In general it may be said that an amount of salt in water equivalent to 200 p.p.m. chlorine may be detected by persons with a delicate sense of taste; 300 p.p.m. chlorine is noticeable to almost anyone; while an amount in excess of 500 p.p.m. is distinctly unpleasant. The following is a summary of daily routine tests over a period of three years.

Results of chemical tests on treated water

YEAR	ALKALINITY			CHLORINE		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	6	14	2	16	300	4
1921	7	17	3	164	3,010	6
1922	6	20	2	17	545	5
	6	20	3	66	3,010	4
	FREE CO_2			TOTAL HARDNESS		
1920	4	14	1	33	59	13
1921	4	10	1	57	322	25
1922	4	10	2	28	45	16
	4	14	1	39	322	13

The following are the averages of monthly nitrogen determinations over a three year period.

Free ammonia	0.022
Alluminoid ammonia	0.088
Nitrogen as nitrite	0.0
Nitrogen nitrate	0.04

Physical characteristics

With the plant operating perfectly the city water is normally soft, with little odor or taste and of pleasing appearance. Owing to the nature of the raw water it is impossible to produce an effluent which is physically perfect at all times. In fact it frequently happens that the tap water in the city is colored or turbid or both. This state of affairs is due primarily to the continual variations in the quality of the raw water. It is partly due to the effect of cold weather on the purification processes which results in the deposition of aluminum hydrate in the treated water as has been explained. It is partly due to the avidity with which soft waters of this type attack iron, the dissolved iron reappearing as a rusty discoloration or precipitate in hot water piping. Finally, it is due to some extent to defects in plant construction and unavoidable errors in operation.

Summary of daily tests for color and turbidity on the treated water

YEAR	COLOR			TURBIDITY		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1920	9	50	0	8	60	0
1921	14	45	0	1	25	0
1922	15	60	0	2	20	0
	13	60	0	4	60	0

Bacteriological characteristics

The filtered water before chlorination would not be considered safe for drinking without further treatment, as will be seen from the following summary.

Summary of the daily bacteriological tests on the filter water (not chlorinated)

YEAR	AVERAGE BACTERIA PER CUBIC CENTIMETER ON AGAR AT 37°C.	AVERAGE B. COLI INDEX; PER 100 CC.
1920	35	73.00
1921	52	16.10
1922	43	21.97
Average............	43	37.02

The filtered water can be sterilized readily by means of liquid chlorine and the resulting effluent meets the Treasury Department

Standard for drinking water on common carriers. However, in accomplishing this the chlorine treatment loses its identity as a factor of safety and becomes a necessary part of the purification process. The following is a summary of bacteriological results on the filtered and chlorinated water over a three year period.

YEAR	TOTAL BACTERIA PER CUBIC CENTIMETER ON GELATINE AT 20°C.			TOTAL BACTERIA PER CUBIC CENTIMETER ON AGAR AT 37°C.			AVERAGE B. COLI INDEX PER 100 cc.
	Average	Maximum	Minimum	Average	Maximum	Minimum	
1920				11	99	0	0.32
1921	15	900	0	24	620	0	0.53
1922	20	600	0	34	1400	0	0.32
	18	900	0	23	1400	0	0.39

Hydrogen ion tests

During the past year a large number of hydrogen ion tests have been made. The colorimetric method without buffers was used (17). The standards and indicators were prepared from materials procured from the LaMotte Chemical Company. The pH values given in this article are not offered as being strictly exact, but simply as determined in the course of routine work. The following table shows the results obtained on the Wilmington water over a period of five months. It will be observed that the average pH value on the basin effluent coincides with the experimental optimum shown in figure 3. That this constitutes a valuable confirmation of the laboratory data is apparent in view of the fact that the basin has been operated primarily to produce the best appearing floc and that the resulting pH has been taken only for confirmation and record.

Results of pH determinations on Wilmington water, 1922

MONTH	NUMBER TESTS	AVERAGE	MAXIMUM	MINIMUM
Raw water				
August	48	6.0	6.4	5.6
September	58	6.3	7.6	5.8
October	60	6.3	6.8	6.0
November	16	6.4	7.0	6.2
December	7	6.5	6.8	6.2
	189	6.3	7.6	5.6

Results of pH determinations on Wilmington water, 1922

MONTH	NUMBER TESTS	AVERAGE	MAXIMUM	MINIMUM
Treated water				
August	45	6.1	6.6	5.8
September	58	6.2	7.8	5.8
October	58	6.3	7.0	5.4
November	13	6.1	6.4	5.8
December	6	6.1	6.3	5.8
	180	6.2	7.8	5.4
First basin effluent				
August	21	4.2	4.4	4.0
September	20	4.3	4.6	4.2
October	25	4.3	4.8	4.1
November	18	4.5	5.2	4.2
December	24	4.9	5.6	4.2
	108	4.4	5.6	4.0

General operating statistics

Table 1 has been prepared to show the operating results on the plant and it includes the most interesting data from the annual report, for three years. The figures for amounts of water treated have been computed from the displacement of the pressure pumps and are not strictly accurate. All other figures except total cost are based on the pumpage and are relatively accurate. The total cost of purifying the water includes low lift pumping, chemicals, labor for pumping and filter operation, repairs and labor on repairs, wash water, supervision and laboratory. It does not include depreciation or cost of pressure pumping.

The average amount of water treated daily is slightly in excess of 3 m.g.d. which is only about one-half the rated capacity of the plant. This explains why the rate of filtration is only 88 instead of 125 m.g.d. It has been found that somewhat more uniform results are obtained at the lower rate. There is very little variation from year to year in the average amounts of chemicals required to treat the water. The decrease in the amount of coal required is due to improvements to the power plant.

TABLE 1

Summary of operating data for three years

YEAR	GENERAL STATISTICS										
	Water filtered (million gallons)		Wash water per cent (average)	Hours in operation per day (average)	Yield million gallon per acre daily (average)	Rate million gallons per acre daily (average)	Length of filtered runs (average hours)	Basin time (average hours)	Average parts per million alkalinity to 1 gr./gal. alum (Basin No. 1)	Average parts per million alkalinity to 1 gr./gal. alum (total)	Pump duty million foot pounds per 100 lb. coal (average)
	Total	Average									
1920	1,158	3.165	2.36	23.6	64	79	56	11.7	5.2	5.5	14.90
1921	1,146	3.140	2.81	21.3	64	83	42	10.4	5.0	6.4	16.00
1922	1,235	3.384	2.93	23.1	69	101	31	9.5	4.2	5.8	17.45
Average...	1,180	3.230	2.70	22.7	66	88	43	10.5	4.8	5.9	16.12

YEAR	COAL AND CHEMICALS (AVERAGES)							ANNUAL COST OF PURIFICATION	
	Alum		Lime		Chlorine		Coal		
	Pounds per million gallons	Grains per gallon	Pounds per million gallons	Grains per gallon	Pounds per million gallons	Grains per gallon	Pounds per million gallons treated	Total cost	Cost per million gallons treated
1920	429	3.00	121	0.85	5.95	0.041	2,497	$36,458.72	$31.48
1921	390	2.73	114	0.80	5.53	0.039	2,367	33,822.20	29.51
1922	403	2.82	104	0.73	5.17	0.036	2,155	35,248.38	28.54
Average...	407	2.85	113	0.79	5.55	0.039	2,340	$35,176.43	$29.84

CONCLUSIONS

The purification of the present raw water requires careful technical supervision both night and day. The dosage of chemicals must be very carefully controlled and at times it must be varied almost continually to meet the changes in the character of the raw water. The process is an expensive one, the average cost per million gallons treated for the three year period being $29.84. Chlorination is necessary to produce an effluent of satisfactory bacteriological quality. In cold weather trouble may be anticipated from the presence of aluminum hydroxide in the filtered water. Laboratory tests and actual experience with the plant indicate that there is an optimum hydrogen ion concentration at which flocculation and decolorization occur and that this point is close to pH 4.4. This

optimum can be secured when the amount of alkali (p.p.m. $CaCO_3$) allowed per one grain per gallon filter alum (17 per cent Al_2O_3) is about 4 to 1. The pH zone for optimum conditions is narrow and outside this zone poor results may be expected. For the purification of this water in cold weather it appears that a long retention period (at least twenty-four hours) or a system for heating the raw water would be advantageous.

After sixteen years experience with this water Wilmington is now in the process of making extensive changes in the water supply system. The changes affecting the filtration plant are:

A new raw water intake on the turbid Northwest (branch) Cape Fear, five miles above the city; installation of electrically driven pumping machinery; the construction of a mixing chamber; installation of dry feed machines for chemicals; modification of the sedimentation basins to reduce velocity; substitution of high velocity for air and water wash; resanding of filters; installation of a Venturi meter.

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THE DEGASIFICATION OF WATER[1]

By J. R. McDermet[2]

The material for this paper is based upon the experiences obtained in the development of a successful apparatus for the degasification of water. Part of it is based upon work in the research laboratory, and part upon results gained in the application of these degasification units located variously over the entire United States, and ranging in capacity from an hourly water-handling rate of 4000 to 1,100,000 pounds. The success of this apparatus is based as much upon the observance of good rules of engineering as upon the proper regard for chemistry, but, because the interest of this audience is primarily directed toward the industrial and potable uses of water, the scope of this paper will be limited to the characteristics of various commercial apparatuses, as they concern water.

Primarily, the apparatus derives its commercial merits from the fact that it is able to prevent corrosion in piping. Several methods are available to secure the same results other than degasification. For instance, certain materials have immunity from specialized corrosion attacks, but none of them is ordinarily able to meet satisfactorily all the conditions which natural waters impose from time to time, and, simultaneously, be within permissible cost. It is also possible, in many cases, to control properly the hydrogen ion concentration of the water so that the pipe lines will be either immune from corrosion or covered with insoluble coatings precipitated from the dissolved solids in the water. These also are objectionable in that it is not alway possible to control the hydrogen ion concentration without interfering with the usefulness of the water, or to precipitate a protective coating which will be permanent. Degasification apparatus, however, has not had an economic field other than the removal of dissolved gases from hot water, the primary reason being that investment costs for large water handling capacities have been greater

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than the damage which cold water corrosion has caused. Water has its maximum corrosive virulence at approximately 180°F., and most waters are relatively harmless at normal atmospheric temperature. Pipe lines of great length or pipe lines carrying salt water may, however, profitably be protected. Degasification of water from a commercial standpoint is an insurance feature for protecting pipe lines.

The degasification of water may be obtained by one of two methods which broadly may be designated as chemical or mechanical. The chemical method is, however, more particularly a de-oxygenation rather than a degasification, in that ordinarily only oxygen is removed in the process and carbon dioxide and hydrogen may actually be increased. The gases which it is generally desired to remove in water degasification processes are the gases dissolved from the air, and consist of oxygen, nitrogen, hydrogen, and carbon dioxide, in proportions regulated by their partial pressure in the atmosphere and their solubility factor in solution.

The chemical method consists in bringing the water to be de-oxygenated, after first heating it, into a tank filled with a collection of high manganese steel scrap; the intention being that the oxygen in the water shall attack the steel scrap and corrode it, this being a cheap and readily replaceable material. The method, therefore, has an immediate attractiveness in that it deals with corrosion in its own terms, and protects pipe lines by destroying the corrosive effect of the water. The oxygen in the water is consumed in producing some form of iron oxide from the scrap iron. Just which oxide will be formed depends upon the temperature, the oxygen concentration in the water entering, and the rate at which the apparatus is operated. Some waters, particularly those high in carbonate and dissolved carbon dioxide, may produce a conglomerate within the iron reaction chamber, which may speedily clog up the apparatus and render it inoperative. In addition, the products of normal reaction in these scrap iron chambers, are colloidal or gelatinous, and are extremely difficult to filter unless the hydrogen ion concentration is controlled by a coagulant within a zone to precipitate the iron oxide in a filterable form. The rust products are of course not dangerous from the standpoint of producing further corrosion, but are extremely distasteful.

There is also an unfortunate tendency for these chemical degasifiers to become inoperative due to polarization, the successive layers of

oxide forming upon the active material and eventually rendering it immune. This disadvantage, however, has been overcome in a foreign type of the apparatus, in which the water is passed through a series of these de-oxygenating chambers, and in which the degasification is through the serial action. The direction of flow through the chambers is periodically reversed, and as a result the ferrous oxide, for instance, which formed at one stage in the previous cycle, itself acts as a vigorous de-oxygenator at a different stage in the following cycle when the flow direction is reversed. This principle of reversibility seems to be a distinct improvement in the art of using this type of degasifier.

The other method of degasification may be designated as that of partial pressure control, and in its various commercial forms is a more or less exact application of Henry's law. Henry's law, stated in its simplest form, is to the effect that permanent gases which do not unite chemically with the liquid, dissolve in the liquid in proportion to their partial pressure on its free surface at any arbitrary temperature. Reduced to a more mathematical form, the solubility is equal to a proportionality constant, dependent upon temperature, nature of gas, chemical character of liquid, etc., times the partial pressure. The partial pressure is that of the particular gas, and the solubility is of course independent of the partial pressure of any other gases which may be present, or the total pressure on the surface of the liquid.

Henry's law immediately suggests a means of degasification, viz., that of bringing the liquid into equilibrium with a gaseous atmosphere in which the partial pressure of the gases, which it is the desire to eliminate, will be reduced substantially to zero. Any method of hastening equilibrium, such as agitation and exposing a large surface, contributes to the operating efficiency of the apparatus.

Several different types of apparatus are available in America for accomplishing this purpose. One of them at least has met with a large measure of commercial success, and is the apparatus with whose development the writer has been directly concerned.

One type of apparatus which has had limited use in connection with small capacities for deaeration of hot water in building service depends upon the fact that at atmospheric boiling point the vapor pressure of the water is equal to the pressure of the atmosphere. In theory, therefore, according to Henry's law, if this water was agitated in a contained space, the pressure of the vapors would be the pres-

sure of the atmosphere, and the enclosed space would be entirely filled with water vapor, together with the small admixture of air with this water vapor as the air was driven off from the liquid. The partial pressure of the air would be substantially zero for the simple reason that the partial pressure of the steam would be substantially atmospheric, and the sum of the two would be equal to the atmospheric value also, the difference amounting to the partial pressure of the air being, therefore, very small. These apparatuses have been fairly successful, and have given values of oxygen as low as 0.4 cc. per liter and corresponding to parts per thousand by volume under standard gas conditions, the usual way of expressing dissolved gases in water. These particular types of degasifiers have suffered the limitation, however, that they are not efficient, for, in the contained atmosphere, which is supposedly of zero partial air tension, diffusion currents have appeared, and it has been impossible to displace the air without considerable heat evolution and a positive convection with steam. When heat energy is liberated in any appreciable quantity, the process invades the realm of another type of degasifier, and any further discussion necessarily must be devoted to this other type.

A second type of degasifier has appeared on the market, in which steam is bubbled upward through nozzles, and in its passage frees the water of air. It is an awkward means of applying the previous description in that the atmosphere is virtually forced upward through the liquid instead of by the more sensible way of raining the liquid down through the atmosphere. The results, however, in the second apparatus are slightly more thorough than in the first, and the difficulties of the apparatus are more mechanical than those of proper degasification.

The Elliott process, with which the writer has been engaged, is named after its inventor, and is called a deaerator instead of a degasifier, primarily from recognition of the fact that the gases which are to be removed are normally the gases of the air. This apparatus operates through heat interchange, and at the same time is 100 per cent thermally efficient. In its operation the water is first heated to some 25 degrees above the temperature at which it is desired to use it, and then injected suddenly into a region of vacuum, in which the pressure is maintained at a value corresponding to the vapor pressure of the water at the temperature of use. These previously mentioned 25 degrees excess temperature are, therefore, available as superheat in the liquid relative to the temperature of the vacuum,

and when the water is injected, the heat immediately flashes some portion of the water into steam, evaporating it and disintegrating the rest completely. After disintegration, the water is collected and further passed back and forth over agitation spray pans to bring it into more complete contact with the atmosphere in the interior of the separating chamber. The vacuum in the separator chamber is maintained by some form of air exhausting equipment in series with a condenser, the function of which is to condense and return to the system the vapors and the heat evolved in the boiling process. The cooling water for this condenser is supplied by the water on its way to the heater, and the heat, therefore, interchanged by the condenser is returned to the heater.

This apparatus obeys Henry's law in these particulars. The water is first disintegrated by the flashing process on entrance into the region of vacuum and equilibrium is hastened by agitation. The water is further agitated over cascade pans. The net result of atomization and agitation is to increase vastly the amount of virtual free surface where the liquid is intimately exposed to the atmosphere on the interior of the separating chamber. This, therefore, is the first qualification under Henry's law. The usual temperatures at which water is used are in vapor pressure regions, in which the pressure is less than atmospheric. The employment of a vacuum, therefore, immediately reduces the total pressure in the region, and, by reducing the total, simultaneously reduces the various constituent partial pressures which comprise the sum. A controlled amount of vapor is evolved in the flashing process, which provides a regulated component of vapor pressure in the separating chamber, and this is regulated on the basis of being substantially equal to the total pressure existing in the region of separation. By the process of substitution, the partial pressure component due to air gases, is reduced substantially to zero, its value in operating apparatus lying invariably below 0.001 inch of mercury pressure, and the solubility of the gases in the water, therefore, corresponds very closely to the theoretical value indicated by this partial air tension. If the water is abstracted, therefore, from this separating chamber and its region of vacuum and put under a positive pressure without further contamination, it will remain substantially gas free.

It has been customary to employ for water free from nitrates and nitrites the Winkler Test for dissolved oxygen, with proper pre-cooling of the liquid to temperature conditions at which the Winkler

Test may be operated. It is ordinarily customary in connection with the Elliott process to speak of the liquid delivered as of zero oxygen content when it does not respond to the starch indicator test in the Winkler titration. Such a condition of oxygen solubility is, however, manifestly untrue, but the zero oxygen of commerce is so defined, and apparatus employing the Elliott process uniformly delivers water having this so-called zero standard.

For waters containing nitrates or nitrites, it is customary to employ the Lenoissier test for dissolved oxygen, which consists of determining the reduction of a calibrated ferrous sulphate solution, using phenol-safranine as an indicator. This method is preferably first calibrated upon a nitrate free water in terms of the Winkler method and then used upon waters for which the Winkler method is inapplicable. It can, however, readily be standardized directly.

The research laboratory has just completed an investigation on the behavior of the Elliott process upon dissolved carbon dioxide. The results will be forthcoming in a paper before the American Chemical Society, by Mr. D. H. Jackson, in collaboration with the present writer. It is possible, however, to summarize the results of this paper in advance by saying that the Deaerator, so-called, and as previously described, removes all free carbon dioxide and decomposes approximately 35 per cent of the bicarbonate present, most of which is precipitated, and a small part, approximately sixteen parts per million, remains in solution as calcium carbonate. This percentage value increases slightly with concentration of bi-carbonate. The pH values are changed by deaeration from slightly acid to decidedly alkaline, the change averaging 2.5 pH. The results were obtained upon water from two surface streams, one in the vicinity of Jeannette, Pa., and the other from Pickering Creek, which supplies a suburb of the City of Philadelphia. The pH values on the raw water for the series of determinations average around 6.7 and the pH on the deaerated samples 9.25. The results were obtained both from gravimetric weighing, volumetric titrations, and from gas evolution and measurement, and afford a fairly accurate check upon each other. The laboratory results have been rather curiously verified by one user of a deaerator who operates a large power laundry in Brooklyn. He has encountered a saving of approximately 35 per cent in the soap employed in the laundry process, and has been much gratified over this particular feature. It appears also that the calcium carbonate precipitated above its intrinsic solubility value comes down first as a

colloidal precipitate, which rapidly granulates and deposits as a sludge. In the large power plant units it does not appear to form the usual boiler scale which is associated with calcium carbonate, and the laboratory is at present investigating the cause. As a matter of conjecture, it may conceivably be a change from the calcite to the aragonite form of crystal. At least this is one of the present theories which the laboratory is attempting to verify.

It is difficult to say, however, whether the removal of dissolved carbon dioxide has primary significance in the prevention of corrosion It has never been the writer's good fortune to have had direct experience with an apparatus which removes only the dissolved oxygen, but it seems reasonably substantiated, from the results of others, that the removal of dissolved oxygen completely rectifies corrosion troubles. The chemical process, as outlined previously in this process for deoxygenating water, does not remove carbon dioxide, and yet it functions very well in preventing corrosion. The Elliott Deaerators remove both air and carbon dioxide, and go even a little further than Henry's law would indicate in removal of carbon dioxide. The carbon dioxide-carbonate equilibrium is of course a reversible one, which is displaced with considerable rapidity under the proper conditions.

Not all water supplies produce corrosion of the same virulence, and it is desirable, therefore, to direct attention to the term aggressive CO_2 as originated by Massink and Heyman on the Water Supplies of Holland, and which has previously been discussed in the proceedings of this Association. Such waters as exhibit CO_2 have pH values almost invariably on the side of acidity. Whether the significance of CO_2 from the corrosion standpoint lies in this pH value is open to question, but it is a matter of experience with the performance of Elliott Deaerators that the regions which exhibit the most severe pipe corrosion are also the regions in which the water either is aggressive, or tends to be aggressive, and in which the pH values are invariably slightly in the acid zone. If water supplies are ever surveyed from a standpoint of potentiality to produce corrosion, this pH value in connection with the CO_2 content is the most significant factor concerning them, provided they are free from contamination due to either sea water or sewerage, neither of which of course would be contained in an industrial and sanitary supply.

It is not reasonable to expect, nor is it found in practice, that any pipe material will be immune from corrosion in the presence of dis-

solved oxygen. It is, however, readily observable in the record of Deaerator sales, that certain localities are very much better customers than others. For instance, the territory bordering both the Atlantic and the Pacific Oceans, with few exceptions, furnishes the best market. The Great Lakes territory furnishes the least. Pipes of average commercial purity have a life along the Atlantic seaboard which varies from six to eight years on the average. In the Great Lakes region, such as Detroit, the usual life varies from fourteen to sixteen years.

In the protection of hot water service pipe lines another advantage for degasification is to be observed, viz.—that stoppage of pipes due to corrosion products is removed. Frequently on aggressive waters the corrosion products so impede the flow as to limit the usefulness of the pipe before it is actually perforated. These corrosion products usually consist of an iron oxide calcium conglomerate of which 70 per cent is iron oxide, usually in the ferric form.

The removal of corrosion products from pipe lines is apparently based upon the reversible reaction of the ferrous-ferric hydroxide equilibrium. The ferrous hydroxide is soluble and does not collect in the pipe, while the ferric hydroxide is decidedly insoluble and in addition acts as a very effective binder for other scale forming material. When deaerated water is fed through a pipe network partly filled with these stoppage products, the ferric hydroxide is slowly reduced to ferrous, and the scale product is to some extent dissolved, but primarily detached and removed as a sludge from some low point in the system. The reversibility of the reaction is very slow, however, and it ordinarily takes in practice from four weeks to three months to clear pipe lines completely. The fact that they can be cleared by this simple process of feeding deaerated water is a big commercial advantage, although not strictly a conservation measure. It does not seem, however, that either the conglomerate, which may be at present mixed with the iron hydroxide, or the removal of CO_2 along with the deaeration process is involved in the removal of corrosion products from pipes, for all types of degasifying apparatus yield virtually the same advantage, the only difference being a question of time, depending slightly upon the degree of oxygen removal which the degasifier secures. It is undoubtedly, however, purely a phenomenon involving oxygen, in which the equilibrium of the ferrous-ferric hydroxide relationship is controlled by the oxygen content of the solution.

It is fairly definitely established that partial deaeration in itself will completely remove corrosion products, and that the minimum value necessary to secure good service in this particular is 0.6 cc. per liter of oxygen. It seems also that the effective removal of corrosion products and the reversing of this previously mentioned equilibrium is also a most excellent gauge of the amount of oxygen which will produce pipe pitting. Corrosion, even when the oxygen content of water is sufficient to remove corrosion products, goes forward actively, but in the ferrous rather than the ferric form, in which the attack is more widely distributed and not localized so rigidly as to form pitting. It has been definitely established in our experience, however, that a minimum value of 0.15 cc. per liter of dissolved oxygen is still sufficient to produce corrosion, and, under the proper temperature conditions encountered in boilers, also to produce pitting. It is also established in the case of boilers and economizers fed with distilled water that corrosion is absolutely prevented if the oxygen content is kept below the zero value as previously defined. The zone lying below 0.15 cc. is, however, not definitely explored in a commercial sense. By this we mean that the results have not been based upon large scale experiments.

Chlorination of water supply does not seem to have any connection with corrosion, except in some few cases of abuse by over-chlorination. The water becomes unpalatable long before it becomes aggressively corrosive. The chemist's procedure in analysis, however, using phenol-phthalein and methyl-orange as indicators for acidity, is open to considerable criticism. It is very desirable to emphasize, as coming from an outside and a commercial point of view, the necessity and the desirability of keeping accurate records upon hydrogen-ion concentration of the water supply. Aside from the purity of the water for potable uses, this factor of hydrogen ion concentration is one of the most significant things about it. The auto-colloidal hypothesis of Friend, in which corrosion is regarded as accelerated by ferric hydroxide colloid is becoming increasingly useful in corrosion engineering work, as opposed to the earlier electrolytic hypothesis of Whitney. This auto-colloidal hypothesis is along with other variables intimately involved with the hydrogen ion concentration, primarily in regard to the stability of the colloid, which is regarded as a catalyte. It is gratifying, therefore, from a commercial and economic point of view, to notice the interest which is being increasingly

displayed in your Association activities toward the proper interpretation of hydrogen-ion concentration in water supply.

Deaeration of water has recently opened up another field of interest to the water works chemist, viz., the possibility of manufacturing clear water ice on water supplies of nominal hardness by the process of deaeration, rather than distillation. The deaeration process on what might arbitrarily be called soft water is equally effective and vastly cheaper, and will probably encourage the extensive use of raw water ice.

It has been extensively demonstrated on a big scale and in a variety of places that deaeration on the normal water supplies, which municipalities furnish may extend the life of pipe lines indefinitely. It is altogether possible, with such improvements in water supply as your Association will make in the future, that deaeration, together with the improved water supplies, will entirely prevent corrosion in a commercial sense.

WATER SOFTENING BY BASE EXCHANGE[1]

By Gerald C. Baker[2]

INTRODUCTION

Certain complex silicates classed as zeolites are used for the softening of water. These compounds are all hydrous complex silicates ordinarily containing varying percentages of iron, aluminium, alkali earth and alkali metals. The zeolites have the property of exchanging their associated bases, sodium and potassium, for others such as calcium, magnesium, manganese, etc., which represent the hardness of water. Upon filtering water through the zeolites this exchange takes place when the hardening salts are in greater molecular proportions than similar combinations of the alkali metals. When exchange has been carried to a certain point the base exchanging power is exhausted, but the minerals may be returned to their original condition by treating with common salt solution. This produces a base-exchange directly opposite to that during the softening period, i.e., the adsorbed hardening salts are replaced by sodium and when the brine is washed out the softener is again in condition to soften water.

NATURE OF THE REACTION OF BASE EXCHANGE

Of the artificial zeolites originally prepared by Dr. Gans (1) the aluminate silicates, i.e., the alkaline earths and the alkali metals combined directly with the aluminate radical through a union of the silica and the alumina, possessed easily exchangeable bases while the aluminium double silicates, i.e., the alkaline earths and the alkalies combined directly with silica, exhibited no exchange properties. The aluminate silicates were prepared by dissolving hydrated alumina in sodium hydroxide and adding hydrated silicic

[1] Abstract of thesis prepared under the direction of Prof. Edward Bartow and submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at the University of Iowa, February, 1922. Presented in abstract at the Philadelphia Convention, May 18, 1922.

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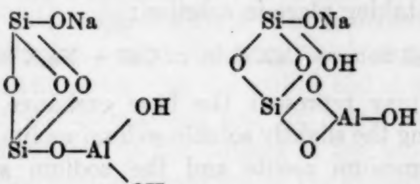
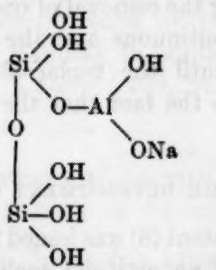
acid while evaporating to dryness on a water bath. The aluminium double silicates were prepared by dissolving hydrated silicic acid in sodium hydroxide and adding hydrated alumina under the same conditions as above. Some of the aluminium double silicates exchanged their bases when warming with sodium hydroxide. An explanation of the non-exchange of bases of some zeolites would be that the bases have replaced the hydroxyl (OH) groups of silicic acid and not that of the alumina. An example of double aluminium silicates would be analcine (2) with the empirical formula Na_2Al_2-$Si_4O_{12} \cdot 2H_2O$, which could be represented graphically, as follows:



Chabasite, an example of the aluminate silicates with the empirical formula $Na_2Al_2Si_4O_{12} \cdot 6H_2O$ might be represented as follows:



According to this theory the sodium combined with the aluminate radical is the replaceable base, while an alkali metal combined with the silicate radical is not replaceable.

G. Weigner (3) attributed the base exchanging properties of the zeolites to colloidal adsorption, basing his conclusions on the fact that the colloidal aluminium hydroxide ($Al(OH)_3$) is positively charged and has a strong adsorptive power for the hydroxyl (OH) ion. The cations in equivalent quantities should be held electrostatically in the gel water.

J. Don (4) and others noted that when hard waters are filtered through permutite, practically all the softening effect takes place very rapidly, showing surface action, and after the sodium on the

surface has been replaced by calcium the reaction depends upon the speed of diffusion of the sodium from the inner portion of the mineral.

Most investigators (5) have generally agreed that the exchange depends on the ion concentration and not on the total concentration, but there are some (6), (7), who believe the change is chemical and not merely adsorption phenomena. If considered chemically the reaction may be represented as taking place ionically. If the zeolite be represented by Z and the reconditioned sodium zeolite by Na_2Z and the hardening salt by CaX we may derive the following equation as taking place in solution:

$$Na_2Z \text{ Soln.} + CaX \text{ Soln.} \rightleftharpoons CaZ + Na_2X \text{ Soln.}$$

This equation may represent the base exchange, the hardening salts precipitating the slightly soluble sodium zeolite as the insoluble calcium or magnesium zeolite and the sodium salts going into solution. The reaction is reversible and will actually take place in either direction depending upon the concentration of the reacting salts. Regeneration is accomplished by having an excess of sodium salts. During softening the removal of one of the reacting products, the sodium salts, is continuous and the reaction proceeds to the right to completion until the replaceable sodium is exhausted. All indications point to the fact that the reactions conform to the law of mass action.

HISTORY OF THE DEVELOPMENT OF THE PROCESS

In January, 1906, a patent (8) was issued to Robert Gans, Germany, for the manufacture of an artificial zeolite (permutite) for use in softening water. Soon after similar patents were taken out in various countries all embodying the preparation of artificial aluminate silicates or similar products, substitutions of boric acid being made for silica, and tin, zinc, lead, zirconium, titanium, iron and chromium oxides, etc., for alumina.

The patents for the preparation of base exchanging zeolites provide for two general methods of manufacture, (*a*) fusion of aluminous or ferrous, etc., material or silicates with alkali silicates or alkali hydroxide or carbonate; and, (*b*) precipitation by treating an alkali aluminate solution with hydrated silicic acid and drying and washing the mass.

Certain natural zeolites have been discovered which possess very readily exchangeable bases, and patents (9), (10) have been issued

providing for the treatment of a clay with sodium salts before and after heating the resulting mass to 600° to 700°C.

Another patent (11) provides for the stabilizing of green sand (glauconite) by heating to 400°C. and its subsequent use as a water softening material.

OPERATION OF ZEOLITIC SOFTENERS

The ordinary zeolitic filter consists of a water tight hollow cylindrical shell for containing the water softening material. The bottom is fitted with some type of strainer system upon which rests a bed of gravel which supports the softening material.

During the softening period the hard water passes into the top of the softener and filters through the zeolitic bed at a rate dependent upon the size of the installation and the hardness of the water. The soft water flows out at the bottom of the tank. The flow is allowed to continue until the capacity of the system is realized, i.e., as long as water of zero hardness is delivered. When the capacity has been exhausted the filter is back-washed by reversing the flow of the water through the filter.

Regeneration is then accomplished by passing a brine solution into the filter and, after standing in contact with the mineral a sufficient length of time, is flushed out, and the filter is again in condition to soften water.

ADVANTAGES AND DISADVANTAGES OF THE ZEOLITIC TREATMENT OVER OTHER METHODS OF WATER SOFTENING

The main *advantages* of the zeolite process are (*a*) a water of zero hardness (*b*) extremely simple operation (*c*) economical operation and (*d*) certainty. The *disadvantages* claimed are (*a*) it gives an increased amount of alkali bicarbonates which may break down and cause corrosion in boilers (*b*) if used for steam raising purposes the boilers must be "blown down" more often (*c*) the water must be free from sediment and (*d*) it is not as economical for extremely hard waters as the lime-soda method.

Balancing the advantages against the disadvantages conditions greatly favor the zeolitic softeners and consequently they are rapidly gaining in public favor for domestic uses, laundries, club houses, textile mills, dyeing plants, bottling works, etc., and steam raising purposes where the raw water is amenable to the zeolitic treatment.

EXPERIMENTAL

The present investigations were undertaken to study some of the more important problems dealing with zeolitic water softeners. The different points investigated are reported under separate headings.

The materials tested consisted of treated greensand "A," an artificial zeolite "B," a treated clay "C" and an artificial zeolite "D." The major part of the work, however, was carried out with the treated greensand (A).

Softening capacity of treated greensand "A"

These tests were carried out both on a laboratory scale and in domestic types of softeners.

a. Amount of salt required for the reconditioning of treated greensand "A." The purpose of these experiments was to ascertain not only the minimum amount of salt which would produce maximum reconditioning of "A," but also the most economical amount of salt to use. Laboratory tests were carried out using University of Iowa tap water, hardness as $CaCO_3$, about 26 grains per gallon, while the results with the domestic installations were obtained in Chicago, using Chicago city water (Lake Michigan water), which had an average hardness, as $CaCO_3$, of 7.65 grains per gallon.

For the laboratory tests one pound of treated greensand was placed in each of six 16-inch calcium chloride towers, the mineral being supported in each case by a layer of glass wool. Seven hundred cubic centimeter separatory funnels served as feed reservoirs for the filters, which were in turn fed from a large carboy (45 liters capacity) by a siphon.

For these tests regeneration was accomplished by adding salt, in dry condition, in varying amount to the different samples. The salt used was Morton's commercial barrel salt and contained appreciable quantities of magnesium and calcium chlorides. Water was then allowed to flow in until the towers were completely filled. The outlets were next opened and water allowed to pass through the filters at a slow rate (600 to 1000 cc. per hour) and tests were made upon the filtered water after the passage of each 100 cc. both for hardness and for chlorides. The amounts of zero hardness water obtained in each case were determined. From the series of tests, 20 grams of salt produced practically as much zero hardness water

as 25 and 30 grams in other filters, while the amount of zero hardness water rapidly increased as the amounts of salt were increased up to that point. Converted to pounds of salt required per pound of treated greensand "A," 20 grams represents 0.044 pound.

For the tests with domestic softeners, a softener containing 480 pounds of mineral was used. Dry salt was also placed in this softener and flushed through at a rate of about 4 gallons per square foot of filtering area per minute. The amounts of salt used varied from 2 to 20 pounds. Morton's salt was used for reconditioning and the source of water supply was Chicago city water. A study of table 1, representing a series of tests, shows that the most efficient amount of salt to use would be about 0.004 pound of salt per pound of mineral. One-half this amount of salt (1 pound) failed to produce any zero hardness softened water.

TABLE 1

Effect of varying amount of salt upon the capacity of treated greensand "A"

POUNDS SALT USED	GALLONS ZERO HARDNESS OBTAINED	GRAINS HARDNESS AS $CaCO_3$ REMOVED PER POUND MINERAL	POUNDS SALT PER POUND MINERAL
2	842	13.4	0.004
4	1030	16.4	0.008
8	1528	24.4	0.017
12	2012	31.9	0.025
16	2159	33.4	0.033
20	2200	35.1	0.042

Although a smaller amount of salt is more efficient, an amount of salt equal to 0.025 pound per pound of mineral is perhaps the most economical amount to use, since in using smaller amounts it would be necessary to recondition the plant more frequently, and the factor of time required for regeneration enters into the question, as well as the amount of water required for back-washing and reconditioning.

Having thus established the optimum amount of salt for reconditioning the material, 0.044 pound for the laboratory tests and 0.025 pound per pound of mineral in the domestic installations, the next work carried out was to determine the capacity of the material both on a laboratory scale and in the domestic installations under varying conditions.

b. Laboratory tests on the capacity of treated greensand "A." The laboratory filters previously described were used in these tests.

The first series of tests was made with University of Iowa tap water, and the regenerations were accomplished as in the preceding laboratory experiments. Later solutions of different degrees of hardness were used in place of tap water.

In the tests with tap water the rates of softening were varied through wide limits. The change did not appreciably affect the capacity of the filters. With constant rates there was a rather wide range in results, hence average results were taken for the capacity of the mineral. These variations may be accounted for by the fact that there was no provision made for back-washing the filters, hence when a channel was formed during a softening period there was no means of breaking it up.

At first sight it would appear that these results carried little meaning, but the variations may be satisfactorily explained by the fact that, all zeolites operate under the law of mass action. When channelling results there is residual replaceable sodium left in the filters, when they no longer deliver water of zero hardness, and a lowered capacity results. If the channels are broken up during the next regeneration practically the same exchange of bases takes place as if all the sodium had been replaced during the previous test, and the material thus contains more replaceable sodium and a higher capacity results.

These tests showed conclusively that the rate of passage of water through the mineral up to a certain rate did not have any effect upon the capacity realized. It also showed that the base-exchanging action of treated greensand "A" is almost instantaneous.

Another point established was that the same amount of wash water was required to free the mineral from hardness and chloride after reconditioning regardless of the rate of flow through the filters. In all cases zero hardness water was obtained before the chloride had been completely washed out.

With rates varying from 250 to 12,950 cc. per hour the average amount of hardness (as $CaCO_3$) removed in 51 tests was 33.2 grains per pound of mineral per regeneration accomplished by 0.044 pound of salt. The average amount of zero hardness water obtained from the tap water (average hardness 26.1 grains per gallon) was 4804 cc. while it required 520 cc. of water to completely wash out the hardness and 1040 cc. to wash out the chlorides after reconditioning.

The next series of tests was made to determine whether the treated greensand "A" had a different capacity for removing hardness when softening waters containing different amounts of hardening salts. These tests were carried out similarly to those using the University tap water, except that synthetic solutions of varying hardness (calcium) were substituted. Table 2 shows the results of these tests.

Since the above results showed such a wide variation, it was decided to devise a set of experiments which would provide a means for breaking up channels formed during filtration, and which would also serve the same purpose as backwashing. Two pounds of

TABLE 2

Capacity of treated greensand "A" for waters of different degrees of hardness under laboratory conditions

HARDNESS OF SOLUTION GRAINS PER GALLON AS $CaCO_3$	GRAINS PER GALLON HARDNESS REMOVED PER POUND MINERAL
5	32.8
10	35.2
15	41.0
20	34.7
25	29.2
30	36.1
Average	34.0

treated greensand "A" were placed in each of three glass tubes 24 inches long and $1\frac{3}{4}$ inches in diameter. One hole rubber stoppers with delivery tubes were placed in each end of the tubes. These served as the inlet and outlet for the solution passing through the mineral. The mineral was supported by glass wool. In these experiments an excess of salt (NaCl) was used for reconditioning. In reconditioning the salt solution was poured into the tubes and agitated in such a manner that all particles of the mineral came directly in contact with the salt solution. The salt was then washed out with distilled water until zero hardness was obtained. A 20 grain per gallon hardness ($CaCO_3$) solution of $CaCl_2$ was then passed through the filters. The average capacity for the tests was a removal of 38.84 grains of hardness per pound of mineral.

An interesting feature was the fact that some of these tests were made by softening upward while others were made by softening downward. The results are tabulated in table 3.

This set of experiments gave higher capacities than the calcium chloride tower experiments, which may largely be accounted for by the improved method of reconditioning in the latter set of experiments. An excess of salt was also used for reconditioning in these tests.

In conclusion it may be said that the average softening capacity of treated greensand "A" under laboratory conditions, when using an excess of salt, varies from 33 to 39 grains of hardness per pound of mineral.

TABLE 3

Capacity of treated greensand "A" when softening downward and upward under laboratory conditions

NUMBER OF EXPERIMENT	GRAIN GALLONS OF HARDNESS REMOVED PER POUND MINERAL			METHOD OF SOFTENING
	Tube 1	Tube 2	Tube 3	
1	42.5	33.8	39.4	Downward
2	37.9	41.6	42.3	Upward
3	40.6	38.0	34.4	Upward
4	40.0	36.2	34.8	Upward
5	36.7	45.6	41.3	Upward
Average.....	39.5	39.05	38.4	

While the laboratory tests have their faults and while there is considerable variation in the results, the data obtained are really worth while, but conclusions must not be drawn from one or two experiments. On the contrary, a large number of tests have been made and the results obtained represent an average capacity of the mineral, largely dependent upon the means used for breaking down the channels formed during the process of softening.

c. Capacity of treated greensand "A" as determined in domestic softeners of different types. The softening capacity of treated greensand "A," using varying amounts of salt, had already been determined in an installation containing 480 pounds of mineral (see table 1). The most economical amount of salt to use for reconditioning was established at 0.025 pound of salt per pound of mineral, and the results obtained with domestic softeners have been with this amount. In all cases regardless of the size of the softener, the dry

salt was added to the softeners and any lumps thoroughly pulverized to permit more rapid solution.

Besides the installation containing 480 pounds of mineral already referred to, additional types of softeners containing 100 pounds and 190 pounds of mineral were used. Chicago city water (Lake Michigan, hardness as $CaCO_3$, 7.65 grains per gallon) and synthetic solutions of varying strength of calcium chloride and magnesium sulfate were used in these tests. In addition to determining the softening capacity, these tests were also made with the view of determining, if possible, the effects of different rates of softening, backwashing, and reconditioning upon the softening capacity of the mineral.

1. Capacities when using three similar installations containing 100 pounds of treated greensand "A" mineral. When using Lake Michigan water, an average of 397 gallons of zero hardness was obtained from 13 tests on each softener. This figure is equivalent to a removal of 30.4 grain gallons per pound of mineral for each softening period. The results varied appreciably and bear out a previous statement regarding the effect of channeling. Somewhat greater capacities were obtained with higher rates of backwash, tending to show the value of a vigorous backwash in breaking up filtering channels. The rate of reconditioning had very little if any effect upon the capacity of the mineral. In other words, the exchange between sodium, and calcium and magnesium is practically instantaneous. Another set of experiments described later will show that with excessively high rates of softening the amounts of soft water are decreased, due no doubt to the packing of the mineral followed by channeling.

In these tests the average amount of water used for backwashing was about 28 gallons, while about 22 gallons were necessary for each reconditioning period.

The next sets of experiments were carried out using synthetic solutions. The water used for preparing these solutions was of zero hardness and was obtained by previously softening Lake Michigan water with a softener containing treated greensand "A." The water was run into a storage tank of 370 gallons capacity and solutions of calcium chloride were prepared which corresponded to a hardness (as $CaCO_3$) of 9.3 and 55.0 grains per gallon respectively. These solutions were allowed to flow by gravity to the softeners. In all cases Lake Michigan water was used for backwashing and reconditioning and,

when zero hardness water was obtained on reconditioning, the synthetic solutions were passed through the softeners to determine the softening capacities towards these solutions.

These tests showed some remarkable results. The average softening capacity, under the conditions, for the 9.3 grain water was 27.2 grain gallons per pound of mineral, while for the 55 grain water the average capacity was only 23.1. The poor results are accounted for as follows. In the first place, due to the lack of pressure, the water passed through the softener at extremely slow rates, which no doubt gave rise to channeling effects. Since the softening capacity for the harder water was much less it was evident that the depth of the bed of mineral was too shallow for good softening conditions, hence these softeners were discarded at this point and two larger softeners containing 190 pounds of mineral were used in their place. A centrifugal pump was also installed in the feed line to furnish sufficient pressure to insure a flow of water fast enough for good softening conditions. The pressure furnished was 38 pounds per square inch.

2. Capacities using two similar installations containing 190 pounds of treated greensand "A." These installations contained a depth of $18\frac{3}{4}$ inches of mineral supported by a bed of two sizes of gravel. For these tests synthetic solutions of both calcium chloride and magnesium sulfate were used. The solutions were prepared from the softened Lake Michigan water in the storage tank already described. The concentrations of the calcium chloride and magnesium sulfate solutions varied from 5 to 60 grains of hardness (as $CaCO_3$) per gallon.

Before these tests were carried out, several experiments were made using the Chicago city supply as the hard water supply. The average softening capacity in these tests was 30.8 grain gallons per pound of mineral. In the tests which followed, Lake water was used for both backwashing and reconditioning. An average of the results of these tests is given in table 4.

For both calcium and magnesium solutions, zero hardness water was obtained only for concentrations of 30 grains (as $CaCO_3$) per gallon or less. For concentrations between 40 and 60 grains small amounts of hardening salts were passed. The results are tabulated in table 5.

It is possible, had a deeper bed of mineral been used, that zero hardness water would have been obtained in these tests. Even a 60 grain hardness water was softened, however, to 1 grain gallon of hardness.

d. Discussion of the capacities of treated greensand "A." From a study of all the capacities of the mineral so far included in this report it will be noted that higher results have been obtained in the laboratory tests. This is largely due to the fact that an excess of salt has been used in all these tests over that used in the experiments for reconditioning the domestic installations.

TABLE 4

Capacity of treated greensand "A" for waters of different degrees of hardness when softening synthetic solutions

HARDNESS OF SOLUTION GRAINS PER GALLON AS $CaCO_3$	GRAIN GALLONS OF HARDNESS REMOVED PER POUND OF MINERAL FOR EACH SOFTENING PERIOD	
	$CaCl_2$ solution	$MgSO_4$ solution
5.0	30.1	
10.0	30.3	29.1
20.0	29.7	28.3
30.0	31.2	32.4
40.0	29.3	33.0
50.0	31.6	30.4
60.0	31.5	30.9
General average........	30.5	30.7

TABLE 5

Degree of softening of extremely hard waters by treated greensand "A"

HARDNESS OF SOLUTION, GRAINS PER GALLON	HARDNESS AS GRAINS PER GALLON REMOVED ON SOFTENING PER POUND OF MINERAL	
	$CaCl_2$ solution	$MgSO_4$ solution
40.0	39.5	
41.3		41.0
50.0	49.0	49.5
60.0	59.0	59.25

In using 0.025 pound of salt per pound of mineral an average capacity of a little over 30 grains of hardness per pound of mineral was obtained under good conditions for domestic installations. Somewhat higher capacities may be obtained if larger amounts of salt are used for reconditioning.

These tests show that the exchange values for calcium and magnesium are the same, i.e., atom for atom. This is in accord with the findings of Hulbert (12) who found it different from Permutit

and Refinite which have higher capacities for calcium than for magnesium.

The rates of exchange with treated greensand "A" also appear to be about the same for calcium as for magnesium. A speed of softening with treated greensand "A" from 2 to 4½ gallons per square foot area per minute gives no appreciable differences in the amounts of soft water obtained for the softeners used in these investigations. It will be remembered, however, that extremely slow rates, i.e., under 1 gallon per square foot area per minute, gave lowered capacities in the installations containing 100 pounds of mineral. Excessively high rates also give a decreased capacity. When softening at a rate of 10 gallons per square foot area per minute in an installation containing 480 pounds of mineral, only 21½ grain gallons of hardness were removed per pound of mineral. The chief difference with excessively high rates is that the mineral packs too hard to get even distribution of the water passing through the bed and channeling results.

TABLE 6

Effect of alkali content of waters upon the softening capacity of treated greensand "A"

RATIO OF CALCIUM TO SODIUM BY WEIGHT		GRAINS HARDNESS (AS $CaCO_3$) REMOVED PER POUND OF MINERAL	PER CENT LOSS OF EFFICIENCY OF MINERAL
Calcium	Sodium		
1	0.0	38.6	
1	1.0	37.8	2.07
1	1.5	35.0	9.30
1	2.0	31.4	18.60
1	3.0	25.3	32.40
1	4.0	11.1	71.30

e. Effect of varying amounts of sodium salts in a constant hardness solution upon the capacity of treated greensand "A." A standard calcium chloride solution equivalent to 20 grains of hardness (as $CaCO_3$) per gallon was used, and laboratory tests were carried out in the tubes already described. The solutions were prepared by using chemically pure sodium chloride in varying quantities with a constant strength calcium chloride solution. An excess of salt was used in the regenerations. The results are tabulated in table 6.

As the alkali content of a water increases with respect to the hardening salts the efficiency of the softening properties of the mineral is decreased. For economical softening the ratio of the alkali

content to calcium must be low. Since the treated greensand "A" has the same capacity for magnesium salts that it has for calcium salts, the calcium-sodium ratios should be applicable to magnesium-sodium ratios. The above data bear out a previous statement that the base exchange of the zeolites follows the law of mass action.

TABLE 7

Average relative solubilities of zeolites in varying strength carbon dioxide solutions

Material dissolved in parts per million

	CARBON DIOXIDE P.P.M.			
	2	10	50	125
Treated greensand "A"	34	101	162	208
Treated clay "C"	41	65	99	150
Artificial zeolite "D"	111	240	280	286

TABLE 8

Average relative solubility per pound of zeolites in varying strength carbon dioxide solutions

Material dissolved in parts per million

	CARBON DIOXIDE P.P.M.			
	2	10	50	125
Treated greensand "A"	25	73	118	151
Treated clay "C"	52	82	124	188
Artificial zeolite "D"	178	384	448	458

GENERAL PROPERTIES OF ZEOLITIC WATER SOFTENERS

a. Effect of carbon dioxide upon different zeolites. These tests were carried out in the calcium chloride towers already described. Distilled water solutions containing varying quantities of carbon dioxide were passed through the zeolites at a constant rate and the soluble material determined by evaporating, drying and weighing. The relative solubility of equal volumes of the different zeolitic waters softeners tested are tabulated in table 7.

The solubility of all the zeolites tested increased with the carbon dioxide content of the water. Volume for volume "C" is the least soluble. The relative solubilities calculated weight for weight show "A" to be the least soluble (table 8).

b. Effect of mineral acids upon zeolitic water softeners. These tests were also carried out in the calcium chloride towers and varying strength solutions of hydrochloric acid were passed through the filters at uniform rates. The results are recorded in table 9.

The zeolites are all fairly soluble in hydrochloric acid, and the solubility increases with the concentration of the acid. All the residues were siliceous in nature. The reaction towards other mineral acids should be similar.

TABLE 9

Average relative solubilities per pound of zeolites in varying strength hydrochloric acid solutions

Material dissolved in parts per million

	HYDROCHLORIC ACID		
	0.001N	0.01N	0.1N
Treated greensand "A"	270	498	3,755
Treated clay "C"	634	811	5,897
Artificial zeolite "D"	490	926	7,827
Artificial zeolite "B"	726	1,390	10,256

TABLE 10

Average relative absorption of potassium hydroxide per pound of zeolite mineral

Material dissolved parts per million

	POTASSIUM HYDROXIDE		
	0.001N	0.01N	0.1N
Treated greensand "A"	7.3	−316	−1530
Treated clay "C"	55.2	−454	−4495
Artificial zeolite "D"	184.8	−302	−2938

Tests carried out showed that the zeolites would not soften water when an appreciable amount of acidity was present. The first tests gave a softened water, but after the alkalinity of the zeolites was neutralized their softening power was destroyed.

c. Effect of alkalies upon zeolitic water softeners. These tests were also carried out in the calcium chloride towers, and in the first series of tests varying strength solutions of potassium hydroxide were used. These tests showed conclusively that, up to a certain point, alkalies are absorbed by the zeolites, i.e. the residues determined after the solutions had passed the zeolites were less than those of the original solutions. The results are tabulated in table 10.

Continued tests showed that after a certain point the absorption became smaller and smaller. Volume for volume there is not much variation among the zeolites tested in their power to absorb alkalies, but weight for weight treated greensand "A" absorbs less than the others. The zeolites satisfactorily removed hardness from these solutions. The residue from the above tests were quite high in carbonates.

A second series of tests were made in which the alkali used was lime water (calcium hydroxide) in varying strengths. In the highest concentrations there was an absorption, while in the lower the residues were greater after passing. The results are tabulated in table 11.

TABLE 11

Average relative absorption of lime water per pound of zeolite mineral

Material dissolved parts per million

	CALCIUM HYDROXIDE		
	0.001N	0.01N	0.04N
Treated greensand "A"	199	52	−581
Treated clay "C"	424	190	−664
Artificial zeolite "D"	235	295	−18
Artificial zeolite "B"	499	212	−1168

These tests bear out the general conclusions derived above that the zeolites absorb alkali. This is especially true of caustic solutions of higher concentrations. In the above set of figures calcium has been exchanged for sodium which appears in the residue. These tests showed the other zeolites superior to "C" in softening caustic solutions. In the 0.04N $Ca(OH)_2$ solution all the zeolites furnished a zero hardness water except "C," which gave a water containing 7 grains of hardness. The original solution contained 120 grains of hardness. It is possible that "C" would have removed all the calcium had the rate been slow enough. In the other solutions "C" furnished a zero hardness water. It is shown, however, that "C" is not as rapid in its exchange action as artificial zeolites "B" and "D," both of which are much slower than treated greensand "A."

To prove definitely that there was an absorption of the hydroxyl (OH) radical, titrations were made before and after passing the caustic solutions through the zeolites with N/50 sulfuric acid, using

both phenolphthalein and methyl orange as indicators. In all cases where there was an absorption of alkali both the phenolphthalein and methyl orange alkalinities were greatly reduced when the solutions were passed through the filters. In the lower concentrations the phenolphthalein alkalinity decreased, but with artificial zeolites "B" and "D" the methyl orange alkalinity increased. This is due to the solution of the carbonates from the zeolites.

The absorption of alkalies by the zeolites appears to be largely an absorption of the whole molecule of the alkali, with an increasing hydration of the zeolitic grains. Volume for volume all the zeolites tested absorbed alkalies to about the same extent, but weight for weight treated greensand "A" absorbed the least.

*d. Comparison of the calcium removed on regeneration to that adsorbed during softening when a 0.01*N *Ca* $(OH)_2$ *solution is softened.* This series of experiments was carried out in the calcium chloride towers, equal volumes of fresh samples of "A," "B," "C" and "D" being used. The testing solution was 0.01N calcium hydroxide ($Ca(OH)_2$), two liters of which were passed through the filters. The water at the end of these periods in all cases was free from hardness. The zeolites were reconditioned with Morton's salt solution in such a manner as to correspond to actual operating conditions of each zeolite. After reconditioning, the zeolites were washed free from hardness and the calcium liberated determined. Correction was made for the calcium content of the salt solution. The ratio of the amount of calcium liberated on reconditioning to that adsorbed during the softening period is given in table 12.

Titrations of the alkalinity were also made on the original solution and the filtered samples to note whether there was any correlation of the amount of calcium adsorbed to the absorption of the hydroxyl (OH) ion.

These titrations showed that "A" at first adsorbed large quantities of causticity which were not liberated on reconditioning, and at the end of these tests the hydroxyl (OH) was still being adsorbed. This was also true with "B" and "C," but the ratios of the original phenolphthalein titrations to the methyl orange were somewhat changed. In the latter tests the methyl orange alkalinity of the water passed through "B" was greater than that of the original solution, showing the solution of carbonates from the mineral.

Titrations were also made upon the reconditioning solutions, and it was noted that caustic alkalinity was in all cases detected in the

water from "A," "B" and "C." Caustic alkalinity was not detected in all cases in the wash water of "D," due to the high solubility of the carbonates of the substance.

These experiments show that the minerals are not thoroughly hydrated and that they may easily become more highly hydrated by the action of caustic solutions.

In all the later tests it seemed that the zeolites had become adjusted to the action of the hydroxyl groups of the calcium hydroxide as their release was proportional to the adsorption. This was true

TABLE 12

Ratio of calcium removed on reconditioning to that absorbed when a 0.01N $Ca(OH)_2$ solution is softened

TEST NUMBER	CALCIUM (MGS.) ADSORBED PLUS Ca OF SALT	CALCIUM LIBERATED (MGS.) + Ca OF SALT			
		"A"	"D"	"C"	"B"
1	566.0	242.2	19.2	366.1	307.5
2	566.0	301.6	42.3	472.8	284.5
3	566.0	463.2	51.9	638.1	470.9
4	560.2	474.7	76.9	559.3	469.0
5	560.2	497.8	124.9	567.0	472.8
6	560.2	197.8	136.5	586.2	494.0
7	539.1	503.6	188.4	503.6	484.4
8	539.1	555.5	215.3	513.2	482.4
9	519.9	484.4	249.9	515.1	528.6
10	523.7	503.6	297.9	513.2	530.5
11	514.1	538.2	342.1	517.0	538.2
12	514.1	510.3	310.4	511.3	500.7
13	514.1	555.5	344.0	528.6	501.7

with "A," "B" and "C." Indications are that the same would have been true for "D" had the experiments been carried to that point. We may explain the fact that the release of the calcium from the zeolites was not quantitative at the start, as follows:

The zeolites contain carbonates. This is especially true of the artificial zeolite "D" tested in these experiments as it was a new sample. When the calcium hydroxide ($Ca(OH)_2$) comes in contact with the carbonate, for example, as sodium carbonate (Na_2CO_3) a precipitation of the calcium is effected according to the reaction—

$$Ca(OH)_2 + Na_2CO_3 \rightarrow 2NaOH + CaCO_3$$

The calcium thus precipitated is insoluble and does not really enter into the base exchange for sodium (Na) during softening. On regeneration the calcium carbonate ($CaCO_3$), not being appreciably soluble in the salt solution, is left as a precipitate.

TESTS ON THE SOLUBILITY OF CALCIUM CARBONATE IN 10 PER CENT SALT SOLUTION

Tests were carried out in an effort to determine whether the calcium carbonate thus precipitated would be soluble in the reconditioning solution.

TABLE 13

Sieve analysis of sand grains

	PER CENT RETAINED ON MESH		
	St. Louis	Columbus	Grand Rapids
20 mesh	0.0	99.9	62.2
40 mesh	86.5	0.1	37.6
60 mesh	13.2	0.0	0.1
80 mesh	0.1	0.0	0.0
100 mesh	0.0	0.0	0.0
Totals	99.8	100.0	99.9

Seidell (13) reports the following solubilities of $CaCO_3$-Water, contact with air dissolves 0.065 gram $CaCO_3$ per liter at 20°C., 10 per cent NaCl contact with air dissolves 0.134 gram $CaCO_3$ per liter at 25°C. Water, free from CO_2 in contact with air, dissolves 0.0128 gram per liter at 18°C.

It would seem, therefore, that the solubility in the reconditioning solution (10 per cent NaCl) of any $CaCO_3$ precipitated on the particles of the zeolites might play an important part in the softening process. With this idea in view tests were carried out upon filter sands coated with $CaCO_3$. These sands had been used after lime-alum or lime-iron coagulations and were typical "growing sand grains." A sieve analysis of the sands gave the following composition.

Equal volumes (400 cc.) of these sands were placed in the calcium chloride towers already described. The resulting weights were: St. Louis sample, 510 grams; Columbus, 552 grams; Grand Rapids, 539 grams. The salt solution used was a 10 per cent salt solution

of commercial salt (Morton's) which contained appreciable amounts of calcium chloride.

The tests were carried out in a manner which would be comparable to reconditioning water softening plants: (*a*) By allowing the salt solution to trickle through the filters, which would correspond to the period of reconditioning of treated greensand "A" and (*b*) allowing the salt solution to stand in contact with the sand grains six to nine hours which would correspond to the period of reconditioning of artificial zeolites "B" and "D" and treated clay "C." The results are given in table 14.

These tests showed a slight solubility of $CaCO_3$ with the St. Louis sample (the finest) except in the case where the contact was

TABLE 14

Solubility of $CaCO_3$ in 10 per cent commercial salt solution

Milligrams Ca per 100 cc. solution

TIME OF CONTACT	Ca CONTENT SALT SOLUTION	SALT SOLUTION AFTER PASSING		
		St. Louis sand	Cleveland sand	Grand Rapids sand
18 minutes	48.4	51.0	46.5	49.7
18 minutes	48.4	50.5	49.0	49.6
6 hours	48.4	56.4	40.4	38.8
6 hours	48.4	49.0	31.0	34.6
9 hours	48.4	47.0	30.5	29.9

9 hours. The coarser sands showed a very slight solubility of the $CaCO_3$ when they were in contact with the salt solution for only eighteen minutes, but upon standing they adsorbed calcium from the salt solution.

These tests show that, where there is enough surface exposed, any $CaCO_3$ precipitated on the zeolitic surfaces would tend to go into solution when treated with 10 per cent commercial salt solution. The solubility is not a function of time, if the salt contains appreciable quantities of calcium. When left in contact with the minerals for a longer time the surfaces may actually keep on adsorbing calcium, the amount of calcium adsorbed being a function of the size of the zeolite grains.

These tests show the need of exercising care in presoftening with lime alone or lime-soda if the water is to be treated with a zeolitic filter.

SUMMARY

Treated greensand "A" is a rapid rate water softening material. The regeneration and softening base exchange of this mineral is practically instantaneous, and rates of softening as high as 4 or 5 gallons per square foot area per minute do not lower its softening capacity. Excessively high rates produce packing of the mineral and channeling results, giving lowered capacities. A certain amount of water pressure is also essential for good softening results. For good softening results a vigorous backwash should be used to break up channels and to remove collected sediment.

A removal of thirty grains of hardness (as $CaCO_3$) per pound of mineral can be expected in domestic installations when softening to zero hardness, if 0.025 pound of salt is used per pound of mineral for reconditioning. Lower amounts of salt are more efficient but 0.025 pound seems the most economical amount to use when all conditions are considered.

The exchange value for calcium and magnesium is the same for treated greensand "A." Other zeolites differ in this respect.

The softening capacity of treated greensand "A" is directly dependent upon the relative concentrations of the hardening salts to the sodium salts of the water being softened; the greater the ratio of the sodium to the hardening salts, the lower the capacity of the mineral.

Both the softening and reconditioning reactions of zeolite water softeners follow the law of mass action. The extremely fast reaction of treated greensand "A" shows the reaction to be largely an adsorptive phenomenon, the reaction being almost entirely on the surface of the grains, while the slower reactions of other zeolites show the reaction to be a combination of both adsorption and absorption. In all cases the reactions are to be considered chemical equilibrium reactions.

The base exchange of zeolite water softeners takes place only in neutral or alkaline solutions.

The solubility of all the common zeolitic water softeners increases in water with increasing carbon dioxide content. The solubility of the natural zeolites is less than the artificially prepared substances.

The zeolites are quite insoluble in alkalies and are rapidly hydrated by their presence. All the common softeners will satisfactorily soften caustic alkaline waters.

It is possible that the softening power of the zeolites is a direct function of their state of hydration, hence reconditioning with caustic alkali gives higher capacities than treatment with alkali chlorides.

The calcium from lime alone or lime-soda pre-softened waters may be quantitatively displaced from zeolitic softeners upon reconditioning, provided such softened waters are thoroughly clarified when passed through them. If the waters are not thoroughly clarified, calcium carbonate may form on the zeolitic grains and impair their action.

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WATER SOFTENING DEMONSTRATION[1]

By Charles P. Hoover[2]

In accordance with Mr. Gwinn's wishes, I am not to present or read a paper, but I am to make a beaker and cylinder exhibition in order to illustrate the lime-soda-ash method of softening water.

The minerals present in water giving it its hardness, are:

1. $CaCO_3CO_2$—calcium carbonate, ordinarily known as limestone.
2. $MgCO_3CO_2$—magnesium carbonate, ordinarily known as magnesite.
3. $CaSO_4$—calcium sulphate, ordinarily known as gypsum.
4. $MgSO_4$—magnesium sulphate, ordinarily known as epsom salts.

Calcium and magnesium carbonates in the water constitute what is known as temporary hardness. These two salts are held in solution by carbon dioxide or carbonic acid, and may be precipitated from the water by the addition of lime, because lime combines with and absorbs the carbonic acid, and, as soon as this acid is eliminated from the water, the carbonates are precipitated. These carbonates can also be precipitated from the water by boiling it. All of you have observed, no doubt, that, when hard water is boiled in a kettle, there is always a mineral deposit in the bottom of the kettle in which the water is boiled, and this mineral is deposited because the carbonic acid has been driven out of the water by the heat.

A few drops of phenolphthalein indicator solution added to water will show the presence or absence of free carbonic acid. You will see that, when I add phenolphthalein indicator to this sample of raw water, there is nothing to indicate that anything has happened, but when I add the same amount to this sample of lime softened water, the sample immediately turns to this beautiful reddish pink color. The results show that the raw river water contains carbonic acid but that the lime treated water does not, and the results are

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

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indicated by the absence or presence of the red color on the addition of the indicator.

Now I will blow, through a tube, into this sample of softened water, colored red by the indicator, and you will see that it immediately loses its color, because in breathing or blowing, I have exhaled carbonic acid which has been absorbed by the water, or, in other words, the water has been recharged with carbonic acid.

If now I take a piece of limestone, which is insoluble in pure water, and crush it into a fine powder and sprinkle it into this carbonated water, it will dissolve because carbonic acid is a solvent for it, and it will stay in solution unless the carbonic acid is gotten rid of.

In order to remove limestone or calcium carbonate from the water, it is necessary, as I have already stated, to absorb or drive off the carbonic acid, and you will see in this next experiment that, when lime is added to the water which I have just carbonated, the red color returns, proving that the carbonic acid has been absorbed.

In commenting on the hardness of water, it is often spoken of as containing lime salts, the presence of these lime salts being the cause of the hardness. In order to understand what takes place in water softening, it is necessary to know the difference between the so-called lime salts (calcium carbonate usually being meant) and lime. Lime is made by burning calcium carbonate or limestone in a kiln. If, for instance, 100 pounds of calcium carbonate or limestone are burned in a kiln, there will be produced 56 pounds of lime and 44 pounds of carbonic acid gas, which goes up the stack of the kiln.

$$\underset{\text{Limestone}}{CaCO_3} + \text{Burning} = \underset{\text{Lime}}{CaO} + \underset{\text{Carbon dioxide}}{CO_2}$$

Now, many chemical reactions are reversible and we have an example of this in the production of lime from limestone. If, as I have already said, calcium carbonate is burned, calcium oxide or lime is formed, whereas, on the other hand, if lime is allowed to cool and is exposed to carbonic acid (ordinary air contains carbonic acid), it reverts back to limestone. Advantage is taken of this reaction in ordinary house plastering. Soft lime plaster is put on the wall, and it gradually becomes hard because, by absorbing carbonic acid from the air, it is converted into or reverts back to limestone, the material from which it was originally made.

In softening water, in order to know how much lime is required, the amount of carbonic acid present in the water must first be deter-

mined. We have already shown that 100 pounds of limestone, when burned, produces 56 pounds of lime and 44 pounds of carbonic acid, and that the reactions taking place in this process are reversible. Therefore, if the results of the water analysis show that 1000 gallons contain, say, 44 pounds of carbonic acid, dissolved, then it would be necessary to add 56 pounds of lime to the 1000 gallons, and this 56 pounds of lime, combining with the 44 pounds of carbonic acid converts it into 100 pounds of insoluble calcium carbonate, which is easily removed from the water, and thus we now see what has happened to the lime itself.

The effect of the lime is to absorb the carbonic acid, and the carbonic acid having been absorbed, the carbonates held in solution by this acid are immediately precipitated and removed, so that, as a result of this treatment, there is in reality nothing added to the water. I want to emphasize this point, because you are aware of the fact that, whenever any municipality undertakes a project to soften or purify its water supply, and the people find out that chemicals are to be used in its treatment, they are immediately opposed to it, because they are afraid that the water will be doped with chemicals or something added that will be injurious to their health. The softening process introduces nothing into the water, nor does it take anything away from the water that will injure the health or comfort of the consumer, softened water being very palatable.

A Columbus physician advised me recently to boil the city water before giving it to our infant child, then remembering my connection with the water department, assured me that he did not mean to infer that the water was not safe from a bacterial standpoint, but reminded me that boiling precipitated the lime salts. Later on, I was advised to add a tablespoon full of saturated lime water to each feeding of milk. A number of gallons of water would be required to furnish the equivalent amount of lime. An analysis of the milk, without the addition of lime, showed that it contained 54 times as much calcium as the city water, so that this evidence is rather convincing that water was not intended as a source of supply for mineral constituents needed by the human body.

The lime treatment removes that part of the hardness known as temporary hardness, but to remove the permanent or incrustant hardness, soda-ash is needed. The cost of removing incrustant hardness, or the cost of soda-ash treatment, is about three times that of lime treatment. Therefore, the cost of softening water depends

not only on its total hardness, but also on how much of the hardness can be removed with lime and how much must be removed with soda-ash.

Why are not all hard municipal water supplies softened? The answer would very likely be (1) on account of the cost, and (2) the fear of deposits of carbonates in the distribution system, meters and hot water systems. These two reasons for not softening a hard municipal water supply are really the only two that I know of that merit consideration.

The saving in soap alone to a community will pay for all costs of softening and in addition to that there will be saved the losses due to extra expense of cisterns and double plumbing systems, losses in hot water heaters and boilers. Recarbonation of the softened water will prevent the formation of deposits in meters and distribution systems so that these reasons are not real objections.

Experiments on carbonation with carbon dioxide gas have been studied in an experimental way during the past year at the Columbus, Ohio, plant. The first experimental plant consisted of carbon dioxide gas in cylinders, applied to the water by means of an Electro Bleaching Gas Company chlorinator. The second plant consisted of a burner for burning coke, a blower sucking the gases from the burning coke and forcing them into an absorber. The third scheme tried out consists in sucking flue gases from the boiler stack of the pumping station, passing these gases through a scrubber and dryer and diffusing the gases into the water to be carbonated through a filtros plate diffuser or a diffuser made with twelve parts of coarse sand and one part of cement.

The question is often raised, "What is the practical limit for water softening in municipal practise?" It depends (1) upon the hardness of the raw water treated, and especially upon the amount of magnesium carbonate present; (2) upon whether or not excess lime and soda-ash treatment is resorted to; and (3) upon the temperature of the water being softened, temperature being a much more important factor than the time of reaction.

At Columbus, Ohio, during the cold winter months, the river water is fortunately highly diluted with flood water, causing the water at this season of the year to be at the lowest hardness. However, it sometimes happens that cold weather precedes the winter rains and it is right at this period when the river water is at its maximum hardness. It has been experienced at the Columbus plant,

that, with the hardness of the river water around 450 parts per million and with low temperature, the practical limit for water softening is about 125 parts per million. With the hardness of the raw water around 350 parts per million, it seems practicable to reduce the hardness to about 100 parts per million. On account of the expense involved, the permanent hardness or incrustant hardness is usually not reduced to less than 40 parts per million. If, however, the entire water supply were to be used exclusively for boiler feed purposes or for laundry work, it would then be practicable to add enough soda-ash to remove all the permanent hardness, and by resorting to excess lime treatment, then neutralizing the excess lime with soda-ash, a water with almost any hardness can be reduced to about 30 parts per million, or about 2 grains per gallon.

Columbus consumers are pleased with a water having a hardness of 85 parts per million, fairly well satisfied with a water having a hardness of 100 parts per million, but complain when the hardness of the water is up around 120 to 125 parts per million.

DISCUSSION

Dow R. Gwinn: I should very much like to have Mr. Hoover tell us about the Plant at Defiance, Ohio, the method used there for adding carbon dioxide to the water.

Charles P. Hoover: You may perhaps be interested to know that Nicholas Hill, who built the water softening and purification plant at Defiance, Ohio, is going to read a paper this afternoon before the Chemical and Bacteriological Section, discussing this plant. I have seen the Defiance plant in operation several times, and briefly the plant is operated as follows: The water is treated with lime, soda-ash and alum, passed through baffled mixing tanks, then allowed to settle for about four hours time, after which it passes through a rectangular shaped basin, which is provided with a false bottom, composed of filtros plates. As the water passes through this basin, carbon dioxide gas, produced by burning coke in a brick furnace, is introduced into the basin under the filtros plates, and the small bubbles of gas coming through the filtros plates are absorbed by the water.

Dow R. Gwinn: Has the application of the carbon dioxide to the water any other advantages?

Charles P. Hoover: Mr. Campion, Superintendent of Water Works at Defiance, Ohio, reported at the last meeting of the Ohio Conference on Water Purification, that, under ordinary operating conditions, the water leaving the carbonation chamber has at all times a better and more distinct floc than the water entering. This condition may be due to the agitation by blowing the gas into the water; or, as has been suggested, there may be some unsolved reactions taking place which improve the floc. Dissolved oxygen tests have shown a slightly increased percentage of saturation in the water after having passed through this basin.

Perhaps an ideal method of producing carbon dioxide gas at a large water softening plant would be to burn limestone and use the lime for water softening purposes and then use the carbon dioxide gases for carbonation.

Oscar E. Bulkeley: Is Mr. Hoover quite certain that this colloidal matter will be removed with carbon dioxide treatment; in other words, has the fact been established that this treatment will accomplish what it is intended to do?

Charles P. Hoover: The Defiance Plant is the only plant that I know of that is now carbonating its entire water supply, and Mr. Campion reported at the Ohio Conference on Water Purification that after fifteen months of operation the sand in the filters appeared to be unchanged as far as deposits were concerned and that no trouble had been experienced from deposits in the meters or in the distribution system. From a chemical standpoint, it is hardly conceivable that any deposition difficulties should occur following carbonation, because after the water is carbonated, there should be no difference between it and thousands of raw water supplies that never have been softened.

Royal S. Buzzell: I should like to ask Mr. Hoover if he has noticed any improvement in the taste of the water after re-carbonating? We have softened the city water supply at Flint, Michigan, for a considerable time. The water is similar in mineral content to the Columbus supply but, when softened with lime, a flat taste sometimes results, which is the cause of complaint by the consumers. A palatable taste is of course demanded and we endeavor to avoid or eliminate any disagreeable taste in the water. We have tried, in

an experimental way, aerating, also re-carbonating after softening and the results have been favorable, eliminating the flat taste and reducing the phenol alkalinity.

Charles P. Hoover: The City of Lansing, Michigan, has recently built and put into operation a small demonstration water softening plant. At this plant there is provided a drinking fountain supplied with softened water, and right alongside is another drinking fountain supplied with unsoftened water. The visitors come to the plant and drink from both fountains and then are asked to tell which is which. Mr. Bulkeley, Superintendent of Water Works at Lansing, Michigan, is in the audience and I should like to have him tell the results of his experiments with the people of Lansing, and the effect of softening, if any, on the taste of water. For a short period of time softened, uncarbonated water was pumped, and later this was followed by softened carbonated water. I should also like to ask him if there was any difference noticed in the water after carbonation.

Oscar E. Bulkeley: It is very difficult to detect any difference in the taste. Lansing has a hard artesian well water which will be used for a number of years to come, as its water supply. The hardness is approximately 350 parts per million. Our engineers propose to reduce this hardness to at least 100 parts per million and probably to 85 parts. A demonstration plant of 10,000 gallons per twenty-four hour capacity, complete in every detail, has been erected, and our people have been invited to come over and taste the water. A heater is provided so that hot water is available for washing. Two wash basins are provided; one for hard water and the other for soft water; two drinking fountains are also placed side by side, but the public is not informed as to which is soft and which is hard water. The attendant asks each visitor to tell which he thinks is soft water and a record is being kept. Before the demonstration began the members of the Water Board felt quite certain that it would be easy to distinguish the difference in taste, but they found it quite difficult actually to determine which was soft and which was hard water.

THE PARK RIDGE PUMPING STATION[1]

By W. T. McClenehan[2]

Anyone at all familiar with the water works game knows that a pumping station is always being remodeled, always changed. Pumps wear out; they become antiquated because of improvements in pump manufacture and they are supplemented by new and larger pumps added because of the city's increased population.

In spite of this constant change men in charge of pumping stations frequently do not realize the value of a well defined plan or program for making future additions to their pumping stations. They have adopted a "sufficient unto the day is the evil thereof" policy and improvements are made because of some immediate necessity forced suddenly upon them. As a result of this indifference many pumping stations have become a patchwork of machinery, pipe and buildings, often poorly related one part to another and sometimes curiosities wonderful to behold. The administration which adopts such a policy is not always to be blamed for its indifference for the men that make it up may be ignorant of the real engineering requirements. In such cases it becomes the duty of the engineer to make the administration see the real value of a well thought out plan for making additions.

In addition to adopting a plan for making improvements a city should occasionally take stock of the improvements it already possesses in the way of machinery, pipe, buildings, etc., to see whether they cannot be better arranged for pumping purposes. A study of this kind is especially advantageous where new equipment or new pumps are about to be added. The saving in friction and power may be considerable and the re-arrangement generally makes for a better looking, more convenient station.

The mayor and city council of Park Ridge, Ill., fully realized that their pumping station had been outgrown and that it needed remodelling. They therefore employed the firm of Pearse, Greeley

[1] Presented before the Illinois Section meeting, March 29, 1922.

[2] Assistant Engineer, Pearse, Greeley & Hansen, Chicago, Ill.

& Hansen last December to study the future requirements of the city and to make plans for improvements needed in the pumping station.

Originally the pumping station consisted of a well drilled into the Potsdam sand stone, an electrically driven deep well pump and a 6-inch main laid in the pump room floor to a standpipe built just west of the pump house. Off of this water main in the pump room floor were taken two 6-inch connections to the city; one leading south to a line in Center Street and one north to a line in Park Avenue. Valves were placed on these three lines, which were exposed in the pump room. No meter was included. It will be seen from this description that the arrangement of the original pumping station was not so bad at the time it was built. However, it was not long before changes were made which upset the arrangement. The standpipe was replaced by an elevated tank involving two connections to the mains in the pump house and providing a new connection to the line in Center Street. A new well was drilled in a southwest room built under the sidewalk on Center Street and connections made thereto. A 12-inch line was laid from the Chicago water system at the City limits and three different connections were made to the Park Ridge mains inside the pump house and one outside. About this time the original well was abandoned. Recently an air lift system was partly installed in the newer well to supplement the water supply received from Chicago in hot weather when the demand in Park Ridge exceeded the amount of water the City of Chicago was willing to sell.

Two centrifugal pumps were bought and one temporarily installed to boost the pressure when the Chicago pressure is low. The intention was to arrange the pumps to take water from the well reservoir also, but this work was never completed.

Such therefore was the situation at the plant when we took hold of it last December. There were no less than 11 different pipe connections to various mains inside the pump house and around the elevated tank. Most of the confusion was caused by the natural growth of the plant, but some of it was caused by incompleted construction. Even the pumper did not know where all the lines were. In fact, he scarcely knew the function of all the valves he had to handle.

Our first work was to locate accurately all valves, pipe lines, etc., inside and outside the building and to obtain the characteristics of

the pumps, motors and air compressor. From a study of the city's past increase in population and from a record of water purchases from Chicago over a period of several months, we estimated that by 1935 the population would be about 6000 and that the maximum twelve hour consumption would be about 1.5 million gallons per twenty-four hours. For short periods during the twelve hours this rate would be exceeded, but the tank we figured would supply the excess consumption. In addition it was estimated that the probable fire demand in 1935 would be about 3 million gallons per twenty-four hours.

The two centrifugal pumps had a combined capacity of around 2 million gallons so that it seemed likely that another pump would be required in the near future. Pipe lines were based on the requirements estimated for 1950 because of the greater life of the pipe. This rate was about 5 million gallons per twenty-four hours.

The problem of a layout was somewhat complicated by the awkward shape of the building which was shaped like a flat iron with but few parallel or right angle walls. In the layout selected, a 12-inch suction line is placed along the south wall on the floor connecting at one end to the Chicago main outside the building and extending into the well reservoir at the other end. Each end of this line will be valved for drawing water from either source of supply. Above the suction line will be placed the discharge header with a valved cross connection between it and the suction line. A venturi meter is to be installed in the discharge line inside the pump house, leaving room for the cutting in of another pump when that pump becomes necessary. The water will be discharged toward the west toward the elevated tank, although the city is largely to the east of the pumps. The reason for this is that existing piping could be utilized to better advantage and that all water could be metered. Besides the largest flow at most times is likely to be into the tank.

Some re-arrangement of the outside piping was found necessary. The most important change is the addition of about 90 feet of 8-inch pipe line to be laid to connect to an important point of intersection. A hydraulically operated valve was placed in a pit outside the pump house at the base of the elevated tank. The operating cock of this valve was placed inside the pump house on a post so as to be easily reached by the pumper in case of fire.

The pumps were so arranged that they would work either in parallel or in series, the change being accomplished by opening or closing one valve.

The switchboard is to be placed on a concrete platform at the level of the street above the pipe lines. The board was a part of a former purchase of pumps and motor equipment and is very good indeed. It has provision on it for no voltage and overload release and is made for push button and for automatic operation using a pressure gage.

We have arranged to place the push button stations on the same post as is placed the cock which operates the hydraulic valve.

The air lift system is being somewhat rearranged and completed so that the well which has been fitted up with the well head can be used this summer. By this arrangement the Engineer can do the following things without leaving the pump room.

1. Draw water from Chicago without pumping.
2. Draw water from Chicago using either or both pumps in parallel or in series.
3. Draw water from the well reservoir using either or both pumps in parallel or in series.
4. Operate the hydraulic valve.
5. Operate the air lift system.

Some old piping in the floor of the pump room can be utilized to discharge into the well reservoir whenever the older well is fitted up for use, which will be whenever the present supplies prove inadequate.

The only new machinery bought is a small vacuum pump to prime the centrifugals when it is necessary to pump from the reservoir.

The cost of the entire work is about $6600 including the building and manhole construction. While this layout is not ideal in every respect, it shows what can be done to an existing pumping station at very small cost utilizing existing equipment so as to make the whole station more serviceable, more workable and better looking.

USE OF HYDRANTS FOR PURPOSES OTHER THAN EXTINGUISHING FIRES[1]

By John W. Toyne[2]

With very few exceptions, every city has at some time been a village without the modern convenience, or more correctly, without the necessity, of a water utility, a condition where every one had his own well and the village maintained the "town pump," where any or all of the inhabitants were welcome at any time and the only cost was working the pump handle. Of course, there were repairs to be made occasionally, but Bill Smith from the hardware store and Si Jones from the implement shop would help the Marshalls put on the new leathers or put in some new poles, and even though it had been out of service for a few days, or weeks, no one was seriously inconvenienced, and no real damage had accrued through the mishap. This was the epoch of the "Bucket Brigade." Eventually, the next stage was reached when the "town pump" supply was augmented by the installation of fire wells, or cisterns, at what was assumed to be advantageous locations and the wet mop and bucket brigade supplemented, if not entirely replaced, by our new fire engine, manned by a volunteer force and operated through the thrilling hours of the fire by the application of man-power to the hand brakes of the wheezy old pump.

Finally a water works system was built, the fire hydrant replaced the cisterns, hose carts replaced the pump and a central pumping station became responsible for the supply and pressure.

Our village had become a town of some consequence and was, through the acquisition of industries, developing both in population and modern civic requirements. Sewers, pavements, curb and walks, buildings and various other enterprises arose that required water service of a temporary nature, all unquestionably for the betterment of the community as a whole, not only in the matter of appearance, but as regards sanitation and public welfare.

[1] Presented before the Superintendents' Session, Detroit Convention, May 25, 1923.

[2] Engineer, South Bend, Indiana.

It was but the outgrowth of the common use of the "town pump" that directed the use of its successor, the public fire hydrant, as the general temporary water service medium. It is not surprising that this use of the fire hydrant became universal, especially in municipally owned water utilities.

So universal is this practice, that I have failed to find a single municipally owned plant, and very few privately owned plants, where service is not rendered, either voluntarily or otherwise.

Within the past month, I was in a small city in northern Indiana, and was informed that no service was permitted from the fire hydrants. In less than an hour I counted a building contractor, a crew cleaning sewers, a teamster watering his team in a tub and a tank wagon filling from the fire hydrant. In two of the cases, Stillson wrenches were being used to operate the hydrants with the usual results. I noted where a number of other hydrants had experienced the same treatment.

I have talked with a number of city officials relative to this practice and I have been surprised at the lack of thought that has been given the two most essential elements entering into the consideration of this abuse of one of the most necessary pieces of fire fighting equipment, cost and reliability.

Thousands of dollars are appropriated for the purpose of fire fighting apparatus—pumpers, hose wagons, deluge sets, aerials, in fact everything that the ingenuity of man can conceive that will tend to assist the firemen in their work of fighting fire. Surely the administrators of our municipal government would be subject to severe criticism if they failed in their duty in this respect. At the same time, permission will be granted to almost any one, desiring water for almost any purpose, to use a fire hydrant, notwithstanding the fact that the hydrant is not designed as a service connection and that its use as such not only builds up an exorbitant maintenance cost but reduces the available fire protection.

This latter statement is not merely assumption based on the law of averages, but is fact, proven by actual conditions that have come under my observation. No doubt parallel cases have come within the experience of almost every one connected with water utility or fire protection work. I will cite one or two instances, not that they are unique or novel in any way, but because they are pertinent to the subject under discussion. A fire alarm was answered in an addition where the streets were badly cut up through

sewer construction. The hydrant that should have been used was tied up with a service line, without even a union and by the time the hose wagon had backed out to another hydrant, the house had burned down. At a hydrant ordinarily used by the street sprinkler for filling purposes, and on which the side cap was usually left open, a handful of small rock was discharged into the fire hose plugging the nozzle and allowing a roof fire, started from an adjacent fire, to gain considerable headway before the hydrant could be closed, the nozzle removed and another substituted. Small boys were severely criticized for dropping the rock into the hydrant, but as I see it, the criticism was directed at the wrong place entirely.

It would be difficult to estimate the cost in property damage and loss of life that has accrued from this practice and that is continuing as one of our disgraces.

When I was asked to "discuss" this subject, the first thought I had was, that it would be much easier to "just cuss it" and the farther I go, the easier it seems.

Really there are no arguments in favor of it. The only question open is, how long will it take the citizens of our communities to wake up to the fact that their lives and properties are being placed under an unnecessary hazard and compel us to stop it.

DISCUSSION

Dow R. Gwinn: It is largely a matter of education and keeping at it to reduce the number of uses for fire hydrants other than for fire fighting purposes. I went through it all. When I went to Terre Haute, I found they had a practice there of giving a contractor a nice little card that looked like a railroad pass, by which he was given permission to use water from the fire hydrants and the amount of the material that he used the water on would be reported at the end of the year. Then I found that the street sprinkler was using the hydrants. I saw one night where he had opened the fire hydrant to fill his tank, and about a week after that there was a fire almost in front of that hydrant and the fire department went there and got everything all fixed, ladders up to the attic window and yelled to the man at the hydrant to turn on the water, but he could not do it because the street sprinkler had used a Stillson wrench on the nut so often that it had rounded off the corners and the fireman could not open it. The result was that the roof burned off the house. Then I started in and tried to put a stop to the practice.

It was not easy. But if the city wants water for flushing a sewer, they call up the water works office and say, "Will you send out the controlling valve on 24th Street and Wabash Avenue?" "Yes, when do you want it?" "Right away." So we will put a man with the controlling valve and hydrant wrench on a bicycle and he goes out and screws the controlling or auxiliary valve on one of the nozzles; then he opens up the hydrant and the city folks use their auxiliary valve instead of using the main valve on the hydrant. When they get through, we go out and shut down the hydrant, take off the controlling valve and examine the hydrant and see that it is in good order. Whenever we have a fire we send one of the men out with a special order slip printed for that purpose and he goes out and examines all the hydrants used by the fire department, to see that they are left in good order, and he makes a written report on each one. A circus comes to town. You might ask, what do we do for him? We make a contract with him for $18 a day, including the time of a man who goes out with the hose and the controlling valve and stays there and watches that hydrant until the circus is through with it. In the meantime, we have the circus man pay the $18 in advance so we are sure of getting the money.

F. M. McElroy: There has been a good deal of discussion about the use of fire hydrants at the conventions I have attended in the past, and we are still discussing them. I do not believe it is possible for a city to prohibit absolutely the use of fire hydrants. I think the larger we grow, the more that becomes impossible. In our community we allow the use of fire hydrants, but it must be under the absolute control of the water department. The application is made at the office for the use of the fire hydrant, the permit is issued and the hydrant is equipped with a hydrant valve and the water turned on to the hydrant so there is no necessity for the main operating valve of the hydrant being used by some one not familiar with it. We have only been able to accomplish this in Racine in the last few years. I came to Racine some twelve or thirteen years ago and at that time the hydrants were being used promiscuously by almost any one. I insisted on the proper use of the hydrants, because I think there are times in the community when it is absolutely necessary that a fire hydrant be used. In Racine we sprinkle the streets from fire hydrants, with the placing of this auxiliary controlling valve on the hydrants. Contractors are required to

come to the water office for permit and we equip the hydrant. It was necessary for me to arrest a local contractor, and in Racine I have a collection of wrenches from fire hydrants made of saw blades, monkey wrenches, Stillson wrenches and numerous other devices that have been used on fire hydrants. I found the top nuts all rounded off where these various devices had been used, and it was necessary to arrest the guilty party or parties and it cost them \$25 to \$50 for using hydrants in this manner. I can state today that there is nobody using fire hydrants in Racine unless we know it. I know it is possible with a little effort to educate the consumer of this class to require him to get permits and use the fire hydrants in a proper manner.

My friend talks about the circuses. In my town a circus has to pay \$25; the circus man may talk his head off about it, but it will cost him \$25 with a man from seven in the morning until five in the afternoon for the use of a hydrant, and anyone else who uses a fire hydrant must get their permit and pay the charges. I find it is possible to control the use of fire hydrants. I think that may be a little more difficult in a larger city, but I believe that the water department should still continue to control the fire hydrants. We have a fully equipped, motorized fire department, costing thousands of dollars, and it does seem to me that the entire equipment is useless in small communities, if we are going to let the fire hydrants get away from our control, and this in part is true in the larger cities. In our community spacings of fire hydrants are very close, and if there should be a hydrant out of order, it does not make very much difference. Nevertheless, we have not had that happen, but in places where the hydrants are farther apart in spacing, I think the hydrants should be under the control of the water department to be sure they are in working order at all times. This cannot be done unless you know how the hydrants are being used.

W. S. Cramer: Have you ever tried putting the responsibility up to the fire chief and making the hydrants part of his fire fighting equipment and not to be used for any other purpose?

F. M. McElroy: We have never tried this and I am of the opinion that this is a matter of local conditions. There may be a great deal of merit in this at some places and it may be possible to do it, but I question it in any of the communities in which I have served. I believe it is the water department's duty to maintain the fire hydrants.

W. S. Cramer: You have to get a chief that will work with you and one with backbone enough to assert himself.

W. S. McElroy: The fire chiefs in the various cities in which I have had charge of the water department have coöperated with the water department and have done everything they could.

W. S. Cramer: Of course the first step to avoid the use of fire hydrants for other than fire purposes is for your street department to put in their own standpipes for their own supplies. If you let them use them indiscriminately, you might as well let everyone else use them.

John Chambers: The Louisville Water Company has no control over fire hydrants. They are owned by the city and are under the supervision of the Board of Public Safety. If any one other than the city itself wishes to use water from fire hydrants he must pay the water company for the water consumed, but he must first secure a permit from the Board of Public Safety. If water is obtained from a fire hydrant for building purposes it is paid for on the basis of the number of cubic feet of concrete or other masonry. Hydrants are installed by contracts by the Board of Public Works on recommendation by the Board of Public Safety. The cost is assessed against property within the assessable area and the hydrants are maintained solely by the Fire Department. Mr. Cramer mentioned hydrants installed especially for use in the sprinkling of streets. There are a number of such hydrants in Louisville, but for some reason city employees prefer to use the 6-inch fire hydrants rather than the 4-inch hydrants installed for sprinkling purposes. The maintenance of either class of hydrants is a source of no expense to the water company.

W. C. Hawley: I have been up against this problem for a long time and appreciate all that was said by the gentleman who read the paper. In our town, not only were they using the hydrants for all sorts of purposes, but were doing it under contract with the municipality providing that they should. After those contracts expired, we provided in the new contracts that the hydrants should not be used for any purpose except fire protection, unless with the written permission of the water company. We had some trouble educating the people up to that standard, but we have got to the point where

water for street sprinkling is taken from separate connections. If they want water for flushing a sewer or washing a pavement, we provide a man to operate the fire hydrant and make a nominal charge for doing so. We are perfectly willing to furnish them with the water in reasonable quantities, but we want to know it. We want to know that the hydrant has been operated so it can be inspected. The fact that in over twenty years we never have had a fire hydrant out of order when needed for service at a fire, is significant. Our worst trouble comes from the contractors who can go into the city of Pittsburgh and get a hydrant wrench. They are supposed to report when a hydrant is used, but if they do not report it to the city of Pittsburgh any more than they report to us, Pittsburgh is losing a lot of revenue. Our contract with the city provides that they shall not use the hydrants except for fire protection and we are getting along very satisfactorily. When we catch him at it we make it as expensive for him as possible, and they are learning.

Henry P. Bohmann: The city of Milwaukee permits the use of fire hydrants for other purposes than fire extinguishing, in the prosecution of construction work under city contract, such as street pavement, construction of sewers, the laying of water mains, the construction of curbing, sidewalks, street pavements, etc. All necessitate the use of water, and if the use of a hydrant is prohibited, I should like to know from what source they are going to get the water.

Dow R. Gwinn: From the service pipes.

Henry P. Bohmann: The street railway company is responsible for the condition of the pavement between its tracks and for one foot outside. That means that all over the city they are making repairs. They naturally use the nearest hydrant. Then there is the telephone company and the gas company. I do not see how it is possible, in a large city, to prohibit the use of fire hydrants.

Dow R. Gwinn: We have all those fellows trained now.

W. S. Cramer: Does the electric company allow them to use electricity for driving their drills and welding apparatus, or does the gas company furnish them gas by direct connection to their

pipes? Why should we care any more about where they get their water than the gas or electric company care about where they get their gas or electricity?

Henry P. Bohmann: That all sounds very well, but in practice it does not work out; and I want to say right here that we have not a single revolving nut that shows the use of a Stillson wrench. Before a man is permitted to use a hydrant, he must take out a permit and make a deposit for the hydrant wrench, and nobody is permitted to use other than an authorized wrench given him by the department, and he must agree to be responsible for any damage done to the hydrant. We have what we call hydrant inspectors and each one is responsible for about 300 hydrants in his district. He oils and greases the hydrants and is responsible for hydrants in his district, and pays particular attention to the hydrants used by contractors. The Fire Department has never yet responded to a fire, winter or summer, and found a hydrant out of order.

A. S. Holway: The street railway company is working through the streets, of our city, Oklahoma City, the boroughs are putting in sewers and pavements and doing work of that kind, but they do not take water from the fire hydrants, they get along without it. We have taken the position that we are under contract with the municipality to furnish fire protection, and if we permit the use of the hydrants for other things, we are assuming a responsibility which may be very serious.

Dow R. Gwinn: They do get along without it.

Alex Milne: The situation is somewhat different as between the powers allotted to a private water company and the right to exercise those powers conferred on the plant operated by the municipality, even under the control of a separate company. You have your city engineer's department carrying on large projects requiring at times a large quantity of water, and if they do not get the use of the water from the nearest fire hydrant, there is going to be friction between the operating water board and the board of works and the one generally placed between two fires is the water superintendent. With us we have our city engineer's department entirely isolated from the water works department and still have a little friction.

Our regulations state that the hydrants shall be used for no other purpose than fire protection and no one shall have the right to operate them but the fire department and the water works employees. In the case of contractors we do occasionally give a permit. He must come to the office, make his application and get his permit, which gives him a hydrant wrench and a control valve. In some cases there is a reducer to $1\frac{1}{2}$ or $1\frac{1}{4}$ inches, or in the case of a small service to $\frac{3}{4}$ inch. Then he makes a deposit covering twice the cost of the goods he gets, which is refunded to him on their return and the payment of his bill. The only one I have trouble with is the city engineer; he has a sewer cleaning machine which takes a lot of water. Occasionally a sewer will get choked and we have touble with him. Only two weeks ago, just before I came away, the foreman of the street department reported to our office that there were two hydrants out of order from which he could get no water. I sent the foreman to one and I went to the other personally; in both cases the engineer's office man had tried to open the hydrant by turning to the right; ours all open by turning to the left; he broke the stems off and naturally could not get any water out of them. We had to take both hydrants out and repair them. Of course we billed the city. Fortunately that happened in the summer. In the twenty-three years I have been operating that plant we have never had the firemen go to a hydrant and not be able to get water. Last winter during the exceptionally severe weather, the only frozen hydrant was the one immediately adjoining the central fire station where the fireman had been fooling with the hydrant in cold weather.

Henry P. Bohmann: In the city of Milwaukee we compel the street car company to sprinkle between the tracks and they use the fire hydrant to draw this water. If we did not permit the use of the fire hydrants except for fires, I suppose the street car company would have to go outside the city to get water. Do you expect that would happen?

Stephen H. Taylor: For street car sprinklers we provided in New Bedford special flush hydrants alongside the car track at various points along the line. The charge for water is made in accordance with the number of tank loads returned by the street car company. When water carts were used special 2-inch hy-

drants were provided for their use, in order to eliminate the use of fire hydrants. Since the more general use of asphalt and cement surface streets, very little street watering is done now.

Rodney C. Wilson: I believe that fire hydrants, while primarily for fire protection, should also be used for other purposes. If other uses do not affect their condition and put them in bad order for fire uses. The majority of the fire hydrants are never used by the fire department, but when needed must be in first class shape.

In our city, Rockford, Ill., of 75,000 people there are many hydrants used for sewer flushing, street sprinkling, and by paving and sidewalk contractors, etc. They are the only available supply, and I believe that the convenience and time saved make the use, for these purposes, economical. The thing we try to guard against is the misuse and indiscriminate use by unauthorized people. The street and sewer departments employ men qualified to open and close hydrants and by simply reporting a hydrant when used we are able to keep a good check of their condition.

We have contractors order construction valves, which we install for them at a nominal charge. When a paving job is finished we are notified to take off the valve, when we also inspect the hydrant. The proper solution of the hydrant problem really resolves itself into only allowing authorized persons, who know how to open and close hydrants, to use them; also aiding contractors, by quick service in installing valves ordered, as well as having periodical hydrant inspection.

Dow R. Gwinn: The gas company want to use water for puddling their trenches; we send a man with a controlling valve and he stays on the job; they pay for the water and pay for the man's time. When he gets through, we know the hydrant is in good order ready for the fire department. If a contractor wants water where he has a street to pave, if the five-eighths taps brought up to the curb are not large enough for him, sometimes they connect up two, but if they have an extra large concrete mixer, we make a tap on the hydrant branch. We do that so that it will not be necessary to dig up the street to shut off at the corporation cock when the contractor is through. We set a meter and we charge him for doing the work and for the material, and then when he is through with the work we take out everything except the corporation cock and

give him credit for the salvage. It does not amount to very much, just the labor of connecting it up; so that takes care of the contractor on street paving. Now for the sidewalk work, they get the water from the service pipes along the different houses, we do not hear from them any more. We are practically all metered. They go in wherever they are working and get the water. Mr. Denman's father said a good many years ago they jay-hawked it. We have a contractor who is going to clean out sewers. He wants a large volume of water and must have it. We put a controlling valve on a fire hydrant and connect it to a three-inch Gem meter by a short piece of hose and furnish him the water. When he gets through, we shut off the hydrant, take off the controlling valve and it is all ready for the fire department, if they want to use it. I do not like to be in a position to make excuses to the chief of the fire department. When they want water, I want them to have it immediately, so they can get it without any trouble with the fire hydrant. So we get along very nicely with the fire department, just as if they were one of us. They are doing their part and we are trying to keep down the fire losses of the city.

Francis D. H. Lawlor: Might I ask if you can tell me of the methods of the Underwriters in rating a city? What deficiencies do they charge to a city if the fire hydrants are used by contractors and other departments?

Dow R. Gwinn: I do not know, because we do not allow them to use them.

Francis D. H. Lawlor: When the Underwriters' engineers inspect a city, they inquire into the use of the fire hydrants. If it makes a difference in the insurance rate paid by the property in the city, it is a pretty serious tax.

Dow R. Gwinn: And somebody has to pay it; the property owner is the man that pays it in fire insurance.

SUPERINTENDENTS' QUESTION BOX SERIES[1]

WHEN WATER IS FURNISHED AT FLAT RATES, WHAT IS DONE WHEN THE CONSUMER CLAIMS HE DOES NOT SPRINKLE?

HENRY P. BOHMANN: The conditions do not prevail in Milwaukee any longer. There was a time when those conditions did prevail and the consumer was charged for this connection unless the threaded hose bib was removed or the thread was spoiled so that he could not use a hose on it.

C. B. KNERR: In Bethlehem, on flat rates, we charge the consumer unless he removes the spigot altogether.

F. C. AMSBARY: At Champaign, Illinois, we treat such cases in exactly the manner described by the gentlemen from Milwaukee, but we have found that they often employ ingenious contrivances for fastening a hose to a hydrant that has had the thread removed. Where we find such cases we shut the water off and insist on a meter going in, and we always carry out that program.

DOW R. GWINN: We had a case where a man drove a small nipple inside of the hose spout on the hydrant and slipped the hose over the nipple so that he got the benefit of sprinkling. In another case they sent a little boy out with a rubber coat on and he would open up the hydrant, put his hand under the faucet and shoot the water over the street first in one direction and then another.

G. W. BRISBIN: I have been in the water business thirty-seven years. The only thing I would add to what has been said is that we have so many meters that we have hardly any cases such as you speak of, but we did make careful inspection when the time for sprinkling came about, or rather was pretty well along, so that when we saw green grass we said "That man is sprinkling, he must pay the rate."

[1] Presented before the Detroit Convention, May 21–25, 1923.

A member whose name was not given related the following experience: We had a little experience that way and we bought some seals and when the customer did not want to sprinkle, we would place the seal, at his request, on the hose connection, and the next quarter or the next six months if we found the seal intact we did not charge him for sprinkling, but if it was broken, he paid for that half year.

ISAAC S. WALKER: I have in mind the sad experience of a certain water works superintendent, now gone to his well earned rest in the great beyond. His rules stipulated that sprinkling would be permitted only between the hours of 6:00 and 8:00 a.m., and 6:00 and 8:00 p.m.; that sprinkling was limited *absolutely* to use of hand hose not larger than $\frac{3}{4}$ inch, that the hose should not be over 25 feet long, that no sprinkling should be done during a fire in the city, etc.

Our friend, through his well intentioned endeavors to uphold the Company's rules on this point, had aroused the ire of certain citizens. One morning, on his travels around the town, he discovered a lady sprinkling out of hours. She was furthermore sprinkling the street, instead of her lawn, which was another infracton of the "rules," which I forgot to mention above. He had the temerity to protest her action, whereupon she proceeded to drench our friend with his own water. It is not recorded that he ever again challenged her rights to sprinkle.

In spite of any rules which could be formulated on this question, if a consumer has water on the premises, and wants to sprinkle, he will sprinkle. And incidentally, he will brag to his neighbors, how he puts one over on the water company. Any attempt to enforce regulations of this character is a mistake. It simply makes an enemy of a consumer who otherwise would be a friend, and good friends are needed in the public utility business.

The answer to the question is—put a meter on the consumer's line, and let him sprinkle to his heart's content—the more the better.

J. M. DIVEN: The first part of Mr. Walker's advice is sound, put on meters, get pay for water used for sprinkling lawns and streets and do not make too many restrictions as to hours, kind of hose, etc. matters which lead to friction if not to an occasional ducking. But, considering the peak of load, are not restrictions, reasonable restrictions as to hours for sprinkling wise and reasonable? In a manufacturing city, in fact in most cities, two-thirds of the day's consumption

is used in the eight working hours, two-thirds of the consumption in one third of the time. This brings a heavy load on the pumps, on the filter plant and on the distribution system. Is it not reasonable to ask citizens not to add to the load at these hours, or even to demand and require that they do not? Cutting out the hours from 8:00 a.m. to 5:00 p.m. leaves them sixteen hours to sprinkle, which ought to satisfy all reasonable demands.

WHERE THERE ARE SEVERAL FAMILIES USING WATER THROUGH ONE METER, HOW MAY COLLECTIONS BE DIVIDED?

G. W. Brisbin: We put on what we call a master meter, and any number of subsidiary meters that the party desires, but we render the bill to the owner of the property. We will not render any bill to the tenants. We give the tenant or the secondary tenant a bill that shows him how much his proportion of the total cost is and that seems to answer the purpose very well. We tried several different ways: letting people have two meters and rendering the bill for the whole to the owner, but that did not work very well, so we said that no meters would be installed unless there was a master meter and then they could put on as many subsidiary meters as they liked.

Henry P. Bohman: In Milwaukee we recognize only one meter, that is, the master meter; if the consumer wishes to put on a sub-meter it must be done privately by him, because we do not recognize sub-meters, for you cannot shut off the water supply to premises controlled by a sub-meter without shutting off the main consumer, and I have found that sometimes the sub-meters register more than the master meter.

Dow R. Gwinn: It is a very good thing to have a landlord pay, but in some cases the landlords object seriously and want you to put in three, four or half a dozen meters and let each tenant pay for their own supply. That makes more or less trouble. We tried for a while to make them start in from the sidewalk, have a separate curb-cock on each, but that seemed to be rather an imposition on the property owner and cost him too much money, so we try as far as we can to make the landlord assume the payment for the water used for the whole house. Of course the landlords complain; they say "this fellow has a grudge against me, I want to get him out and he will not move out and so he lets the water run and makes me pay a great big bill for it." I heard of one case where a landlord told each tenant he was paying about so much a year for water, and said, "Now I have

allowed $2 a month for your water bill; if my water bill runs up very much more than my estimate, you will have to pay more rent," and he said it was working out very nicely because each one then had an incentive to look after the water. We had some cards printed in red ink, which we distribute among our customers that they can paste up where the water is being used, a notice to the tenant that if there is a leak in any of the water closets or faucets, to notify someone and then fill in the name of the person to whom they want to refer.

ARE DEPOSITS DEMANDED WHERE WATER IS FURNISHED BY METER? IF SO, HOW MUCH AND DOES THE COMPANY OR DEPARTMENT PAY INTEREST?

Dow R. Gwinn: In our case we ask for a deposit, $3, in the case of dwelling houses, unless the owner lives in the property or will be responsible for it. We allow them 4 per cent interest on deposits if they remain six months or longer. It has worked out very well.

F. C. Amsbary: At Champaign, Illinois, we followed the same method as Mr. Gwinn, has just told us of, until quite recently, when the Illinois Commerce Commission issued a bulletin laying down rules that we must follow in the case of deposits or guarantees. But after studying those rules and regulations we found they were so complicated that we decided to abandon the charging or the practice of requiring a deposit, taking our chances on losses. We think it would cost more to carry out these rules in bookkeeping and investigations than our losses would be if we required no deposit. Fortunately the Commission states that there is no objection to a water company extending credit to any consumer.

Ray Crozier: At Peoria we make the property owner entirely responsible. In signing the application he agrees to be responsible for his water bill. If he wishes the bill sent to the tenant we do that for him, but in case the tenant does not pay, we hold him responsible. At the end of thirty days we shut off the water unless the bill is paid. In that way we have very few losses.

Henry P. Bohmann: In Milwaukee water rates are assessed directly against the property served so that we do not have the troubles that private companies have. Water rates are a lien on the premises and while our revenue is about $2,000,000 a year, we have yet to charge off the first dollar to profit and loss.

Dow R. Gwinn: You run no risk if you take a man's property.

James E. Gibson: In Charleston, S. C., we use the same method as Mr. Gwinn, except that we allow the customer 6 per cent interest on his deposit. We do not keep a separate account of this money, but deposit it in our regular checking account. We pay no interest for a shorter period than three months. We accept no guarantees from the owner unless he signs the regular prescribed form of contract and we insist upon sending the bill to him unless he makes a deposit, in which case we will send the bill to the tenant. We get stuck a good many times. The amount of the bill, for instance, may run to $25 and the consumer has only a $5 deposit. The customer promptly moves or disappears and we lose track of him. Under these circumstances we confiscate the $5 deposit, and put the customer's name and amount on our black list. I might add that our black list is now beginning to pay dividends. I think last year we collected more on our black list than we charged off for bad debts. In South Carolina the water bill is not a lien on the property, either municipal or private. Some of the municipalities by ordinances make the bill a lien on the property, but this is simply bluffing it through; other municipalities refuse to make contracts except with the property holder. We have not followed either of these courses in Charleston, as the custom of the former company was to make contracts with anyone and the only change we have made is to insist upon a deposit where the consumer is not the owner of the property taking the water.

Dow R. Gwinn: We ask a higher deposit from a livery stable or a soft drink parlor, $5 or $10, according to how the bills have been running. We call it an advance payment, and where the customer makes an advance payment of $3, $8 or $10 we charge him each month for the water used and send him a statement showing the amount still to his credit. He gets no interest on that, but it saves him the trouble of making out a check every month for the bill. We have about 100 of our customers who do that. There is one water works down in our neighborhood that has an arrangement whereby they deposit the bill in the customer's bank and they give instructions to the banker to charge the bill to their account the same as a check. That also works out very nicely.

Ray Crozier: Do you think that would work out very well with a meter? Telephone companies do that on a flat rate basis, but if a man had an excess or a leak or something like that, it would work a hardship. He would have to check up his bank account every month.

Dow R. Gwinn: It might wipe it out. But water bills are so small they seem insignificant.

H. T. Watts: At our plant, Vincennes, Ind., we are charging deposits in accordance with the rule of the commission. I think it went into effect sometime in 1917. I do not recall its exact stipulations, but it prescribes that we cannot set up a deposit charge of more than 50 per cent in excess of an average monthly bill, so the charges run something like $1.50 on a ⅝ meter and up to $6 and $7 on a 4-inch meter. One of the provisions is that we shall only charge these deposits in certain cases. That is, it is not the intention to charge them in all cases, but only when there is a doubt as to our ability to collect. It also says that deposits shall be charged in such a manner as not to discriminate against consumers. Those two requirements conflict; if you charge one consumer a deposit and do not charge another, you immediately have the one that you did charge on your trail. So you have discrimination right there, if you attempt to follow out this ruling of the Indiana Commission. That is the way it worked out there. It has been in effect about six years and I think we only have about $400 altogether in our deposit fund. At Chester, we have about $34,000 or $35,000 of deposit money on which interest is paid at 4 per cent. It is not compounded but simple interest; the compounding of such small amounts we have never gone into, but we exact a deposit from every consumer in Chester, and there is no discrimination between tenants and property owners.

Dow R. Gwinn: The water works company must be the judge of whether a man should make a deposit or not. I would not ask a banker to make a deposit. I have a form of letter I use where the clerks take a deposit from a man that I know is perfectly good and when I come across a case of that kind, we send him one of these letters saying that the clerk was perfectly right in taking the deposit because we required them to take deposits, "but you are not one of those kind of people; if you bring this letter to the office, the money will be refunded;" and a man appreciates that.

Stephen H. Taylor: At New Bedford, Mass., we require an advance payment of $5 a year as a minimum charge, also $1.50 to $3.25 a year meter rental, according to size of meter; that allows the

use of water to the value of $5. We render bills quarterly for the excess, and if these bills are not paid within a reasonable time, we shut off the water. We have no other advance payment. We recognize only the owner of the property in our collections. Sometimes as a matter of convenience we send the bill to the tenant, but if he does not pay, the owner is still held responsible. In fact, he signs an agreement to be responsible before the water service is put into his property. If the owner wants to subdivide it he puts in meters inside at his own expense, but bills are rendered to the owner for the amount indicated by the main meter.

Dow R. Gwinn: They had a case in Massachusetts where they had a minimum charge of $10 and at the beginning of the year every customer had to make a payment of $10 to begin with. Then they did not get any more bills from the water department until the $10 had been used up. I thought that was about the nicest way I ever heard of, but, with privately owned water works, we would have a pretty hard time trying to get men to come to our office and lay $10 down on the counter. It is hard enough to get them to lay down $1.

Stephen H. Taylor: That is what we do at New Bedford, except that our charge is $5.

F. T. Lamey: Our consumer in Chester, Pa., deposits $3 for a $\frac{5}{8}$ meter and up to $12.50 for larger meters. We make everybody pay. Every tenant, who comes in and presents a letter from his landlord authorizing us to sign him for his service, must make his deposit. We undertook to pick out a few isolated ones that we thought were all right and we got into hot water because Tom Jones would come in and we'd think he was all right, and maybe the next week John Smith would come in and we would make him make a deposit. One would tell the other and we found it was a pretty ticklish job having a man come to the counter and show his deposit slip and have to tell him that we did not consider him a good payer of bills and he had to make a deposit. So we turned around and required everybody, even the highest banker in town, to make a deposit. With that class of people we find we get along better with the explanation that it is a matter of business. We get along far better than if we tell a man we do not think he is any good, for it makes him angry at once. We do not have any trouble. We have about $35,000 collected on deposits and a lot of money in that fund

that I do not suppose we will ever have to return, money of people who moved away and we do not know where they went. Our population was made up of transient tenants during war times and they moved away. Many of them were foreigners and others skipped out after a bad leak and we had to confiscate the $3 deposit to offset a $25 leak or thereabouts. We get along pretty well now and work along every month trying to eliminate the old ones wherever we find them. Then we notify them to come and get their deposit. That is the way we get over it, by making everybody pay.

P. J. Hurtgen: In Kenosha, Wis., we make the owner of the property sign up for the meter and then we hold the property for the amount of the water bill, and if it is not paid within a certain length of time the water is shut off. As far as repairs and such as that are concerned, if for any reason we do not get it, it goes on to the tax bill. It seems to me that this thing of making one man make a deposit and not another is not exactly right. I think they should all be treated alike and that will be a more popular plan than to require it of one and not of another.

Charles B. Yobst: Fort Wayne does not require any deposits. We have a contract card and any freeholder who will sign the contract has the privilege of using water and we do not have a bit of trouble.

James E. Gibson: I would like to ask Mr. Walker and the gentleman from Chester what they do when a man does not pay his bill. We have this trouble in that we require a customer to put up a deposit of not less than $5 when he is not the owner of the property. His bill each quarter amounts to a minimum of $3.00. The bill is mailed to him, and, if at the end of ten days it is not paid, we send him a final delinquent notice and if we do not get a response from this notice within five days we shut the water off. Immediately he comes forward with the statement, "You have got $5 of my money; why do you not take it out of that rather than shut me off and charge me a fee for restoration of service?" I should like to know how they handle this condition at Chester. We answer this query with the statement that we are paying him interest on the $5 deposit and consider we have no right to touch that money on deposit, until he ultimately refuses to pay the bill, but you can readily see that this answer does not always satisfy the consumer.

F. T. Lamey: At Chester, Pa., we follow along the same lines you do, only we charge him $2 to get the water back in place of $1. We often have them come in and claim that we have no right to turn off the water unless their bill amounted to more than the $3 deposit which it invariably does before we shut them off. The only ones we do not like to shut off are the 58 cent minimum bills. We have two minima, 58 cents and $1.15. A man has to run several months at 58 cents before he eats up his $3 deposit, then we have his $3 and shut him off for a couple of months at 58 cents and then charge him $2 extra and we hate to see that done. We have a case in Chester of a business man who has never paid a bill on time, probably in the last five years. He has his place of business in the house where he lives and he has three tenant houses. He takes care of all the bills about every other month; we shut the whole outfit off and he pays $2 apiece and he never pays until we shut them off; then he comes in and pays and has a nice pleasant talk. He says, "Oh yes. I know that's your rule. I have got no kick coming, it is my fault, but I forgot it," but I honestly feel more ashamed about doing that every second month than some of these others.

Isaac S. Walker: Supplementing Mr. Lamey's remarks, I might say that we have no penalties in Chester. We have no way to encourage them to pay their bills promptly and if they do not pay them the only thing to do is to shut them off under the present rule, which is a very sad state of affairs.

Chester R. McFarland: Our Company, The Tampa Water Works Company, requires a deposit of $5. This deposit is to cover any unpaid bills at the time of vacating the premises. We do not pay interest on these deposits, but we believe it should be done. We render all meter bills on the first of the month and the flat rate bills are payable at the office between the first and tenth of each quarter, that is, January, April, July and October.

All bills paid on or before the tenth of the month in which they are due are subject to a discount of 10 per cent; after that date, payable without discount. The bills are then given to a collector who presents them and, if not paid, a notice is left stating the bill will not again be presented and if not paid at the office in a reasonable time, usually about five days (which time is stated in the notice), the water will be cut off without further notice. If it is not paid, the bill is then given

to the turn off employee and he again presents the bill and if not paid, the water is cut off. Before it is again turned on, the consumer must pay all bills due and a fee of 50 cents for turning on the water.

The Company finds this method quite effective and the losses for bad accounts are small at the end of the year.

The Company finds the method of allowing discount quite satisfactory, as about 90 per cent of the consumers take advantage of the discount and pay their bills on or before the tenth of the month. This has good results in two ways, the customer is pleased to get the discount and the Company is saved much labor and expense.

Robert E. Daugherty: In West Palm Beach we have two municipalities to deal with, Palm Beach and West Palm Beach. We require no deposit for the meter, but in Palm Beach we do require an annual payment of $30 which allows a stipulated quantity of water. The bills in Palm Beach are rendered once a year, because we are unable to reach our consumers in Palm Beach except during the three months of the season, January, February and March. Those bills are rendered on the first of January, and all water used over and above the allowance is included on the bill next January. Those bills are payable by the 15th of the month. The bills in Palm Beach run very large; to give you an idea, we have fifteen or twenty homes in Palm Beach that have 4-inch meters and one man the other day gave me an order for a 6-inch meter for his small residence. In West Palm Beach our bills are rendered for $3.60 a quarter, payable in advance, allowing a certain quantity of water and the same procedure followed as just outlined for Palm Beach. We have perhaps 75 per cent of our consumers in West Palm Beach that have excess water which is billed on the bill with the $3.60 for the next three months. The only penalty we have is that, if the bill is not paid within fifteen days after it is rendered, the water is turned off and $1 is charged to turn it on. We find that is a pretty good rule to live up to, because we charge off very few bad debts and the system works out very well with us. Of course, we have conditions that would not apply in many other cases.

W. B. Livezey: In Newport News we do not charge a deposit. We have quarterly bills for domestic service, monthly bills for commercial service. We have minimum charges payable in advance, for a stipulated amount of water. We do not charge anything for

turning on the supplies. Our curb box key is our best collector; we have very few delinquencies and not many losses. We have a fairly large floating population, and for that reason we must collect in advance.

J. F. Willett: In Billings, Montana, we have a minimum charge of $5 for all tenants. We require no deposit from a property owner. We pay 6 per cent interest on deposits. We are 100 per cent metered and there is no charge for turning water off and on except for collections, which charge is $1.

F. A. Bunks: At St. Joseph, Michigan, our collection system differs somewhat from any I have heard given here today. We hold all property owners responsible for all water used on their premises. The property owner must make application for water to be turned on. For this reason we demand no deposits when turning on the water supply. All bills are rendered quarterly, except where large quantities of water are used and these we bill monthly.

When we find a customer lagging with his payments we send him a shutoff notice; but it is seldom that it becomes necessary to shut off the water.

At the end of the year we find some customers, to whom we have granted time extensions in payment of bills, have not paid as per this agreement and we begin a collection campaign. We notify the public through the local papers that the water will be shut off at a given time if all back bills are not paid in full at that time. A few days after this given date we again use the local papers notifying the public that we are using the water key and if they do not want the inconvenience of being without a water supply to come in at once and pay up. It does not become necessary to use the key on more than one half of one per cent of our customers.

Our greatest loss is from small manufacturing concerns just starting that will do business for a few months and then go to the wall.

Alex Lindsay: I like the attitude of the gentleman who has just spoken. It is apt to arouse resentment in the consumer and also reflects on the ability of the department as a collector to resort to turning off water services. Most consumers will pay their water bills if given reasonable opportunity. Those who are financially unable to pay should be reported to some charitable society for aid. In

Spokane, Wash., we turn such cases over to the city's Social Service Bureau, which institutes an investigation and in proper cases pays the water bill as well as other bills involved in the community care of the family.

Dow R. Gwinn: Still you have to shut off sometimes.

Alex Lindsay: Our water bills are sent out on the first of the month and on the 20th they become delinquent. Instead of cutting off those who have failed to pay on or after the 20th, notices of delinquency are sent to the properties involved. This brings payment of a large proportion of the back bills. Ten days later a second notice is sent to the places still remaining delinquent. Not until after this second notice is the list of remaining delinquents turned over to the chief inspector for turning off services. We have 28,000 services in Spokane. During the last five years we have shut off for delinquency an average of only about 30 services per month, and the majority of these had become vacant after the meter reading was taken. If a water bill is not paid within a year, and we have very few of these, a lien is filed against the property served. As a result of our practice in this matter, we have no uncollectable bills, and very few cutoffs which have inconvenienced householders.

Dow R. Gwinn: That is different; there is a whole lot of difference in running a city water works, where you have a lien on the property, and a water works where the company has to hustle out and get the money in order to pay the taxes.

Stephen H. Taylor: At New Bedford all bills are due quarterly, beginning July 1. Under the old regulations, bills remaining unpaid on the 15th of the month may result in shut off for nonpayment. The old method was to send a man as soon after the fifteen days as convenient either to collect the bill or to shut off the water. The result was that many people acquired the habit of waiting for us to come and collect the bill. Under the new rule, fifteen days after a bill becomes due, we issue a written demand on which 10 per cent of the amount of the bill is added. If the bill remains unpaid thirty days, we shut off the water without further notice and make a charge of $2 additional before it can be turned on again.

William R. Young: In Minneapolis we find that by waiting for notices to be sent to the delinquents, as the last speaker said, people wait for those notices. With us, we send a regular notice on the first of the month and on the 20th of the month that bill becomes delinquent, although there are no penalites until after the water is turned off. In a municipal plant such as ours, however, we wait until we send a second notice giving the occupants a chance to come in and pay their bill, and then we make our delinquent notices out and send them to our street service department which sends its men around serving another written notice, giving them twenty-four hours to pay the bill. If they do not pay the bill at that time, we charge them a $3 penalty, because we found that a great many people waited for that third notice and there was no necessity for their waiting for the third notice. By turning them off, we have no trouble getting the money. A speaker said they lose money on the manufacturers, but we do not lose any money on any of them because the water is turned off and the piece of property that may have that water connection does not have any service for water until all back charges are paid, together with the penalties for turning off or repairs if necessary to the stopcocks. It has been suggested by some that we reduce the $3 charge to a $1 charge, but every fall in the northern country there are a great many vacant houses and we have a charge of $1 for turning off water for temporary vacancy and the real estate men who may have 30 or 40 or 50 houses would let the delinquent bills go if we had the $1 charge until such time as they rented the house again, but, with the $3 penalty, they will immediately come in and pay the bill and we do not have to carry the unpaid bill until such a time as they want to use the water again.

Charles Evans: In Lima, Ohio, we try to be lenient with the public and give them a whole lot of notices and half of them swear they did not get them. We have added a 10 per cent penalty to the bill which is payable quarterly and we turn their water off if they do not pay it by the 20th of the month. The bill is due on the 1st and payable on the 10th and after the 10th the penalty goes on. Around about the 20th if they are not paid, we shut the water off. We add the penalty when we turn it on. If they do not pay their water bills and it runs over three months, there is another 10 per cent penalty added. We have found that the best way to notify them is after turning the water off and they will not come back and tell you that

they never got a notice of that kind. Now Lima is a growing town and there is a shortage of houses. Whenever a house becomes delinquent, it is not delinquent very long, because somebody wants to move into that house as soon as the tenant moves out, so we are not bothered very much. But we have become stringent on this penalty. We found that the easier you are with the public, the more they will take advantage of you, so we turn the water off and then notify them that it is off and tell them why, and they come in and pay.

ALEX. MILNE: This is getting quite interesting and sounds like home. I have not heard any of the speakers remark what percentage of delinquents they have on their roll. Our methods in St. Catharine's, Ontario, are very similar to those of Mr. Young at Minneapolis. We give a discount of 10 per cent if the bills are paid on or before the 20th of the first month of the quarter. If they are not paid on the 20th, the discount lapses and the bill becomes delinquent; if not paid on the last day of the quarter, 5 per cent is added and at the expiration of ten days a special peremptory notice is sent all delinquents giving them until the 20th when the water may be shut off without further notice. With a little over 6000 flat rate consumers, we turned off one consumer last week. The water tax becomes automatically a lien on the property, but strange to relate, I find that the majority of my delinquents are nearly always the same bunch from one quarter to another; 90 per cent are perfectly able to pay the rates. Our best payers today are the despised Polacks and Italians living in the shack districts in the suburbs; they pay their bills promptly and take all discounts.

JAMES E. GIBSON: I wish I could say that we had only turned off one customer in the last six or twelve months. We have to turn off on the average of about sixty each month for nonpayment of account. We have the continuous system of reading meters; that is, we read approximately 200 meters each day and send out bills for a like number. Therefore, the bills are paid at about this rate, two hundred per day.

When the service is discontinued for nonpayment of bill we refuse to restore the service until a payment of a fee of one dollar for restoration of service is made. The only exception to this rule is in case the party has moved and a new party has taken the premises, in which case we compel the new occupant to enter into a new contract and assume the water bill from the last reading of the meter.

Our experience is about the same as at St. Catharine's in that those who can afford to pay are slow to pay, and the best cash customer we have in Charleston to-day is the negro. He does not expect accommodations, does not ask for them, and, therefore, pays as he goes.

Dow R. Gwinn: We have digressed a little bit from the original subject, but this is your meeting and if this is what you want to talk about, that is what we are going to talk about, so I will tell you what we are doing in Terre Haute. We started out this morning reading our meters for the month. We collect monthly and on the last day of the month the bills are due for the current month and we send those bills out to the premises giving everyone an opportunity to pay. We get in some extra help, a number of ladies who are doing their own work at home; they come down and make $3.50 by working from 8:00 a.m. to 5:00 p.m. We do that once a month; it takes about two days to deliver our bills. They are divided up into thirty-five routes. Forty per cent of the bills are paid when they are delivered. We do not employ collectors, but we employ bill deliverers who deliver the bills to the premises and give the consumers an opportunity to pay if they want to and save the trouble of coming down to the office. If the bills are not paid we do not make a second trip unless there is something unusual like sickness in the family and they telephone they would like to have us come out. They have ten days in which to pay. On the eleventh of the month there is 10 per cent added to every bill, and we collect it. On the evening of the 11th we mail delinquent notices to those who have not paid.

Mr. Milne raised the question about how many delinquents we had. A delinquent is one who had used water and had about twenty days more leeway. All but 7 per cent of the bills are paid by the 10th of the month; then we send out notices on the 11th and get a grand rush the next day; they are the ones who forget or who were out of the city, but the balance are the ones who are on the delinquent list every month. About the 14th of the month we send out notices saying, "We will not guarantee you a water supply unless the bill is paid by the 16th." That brings in a lot more of them. Then on the morning of the 17th we start our men out. They are kind hearted men and they do not like to shut off the water. After one man came back from making the rounds he was asked, "How many did you shut off?" and he replied, "I did not shut off any." "But you had orders to shut them off." "Yes, but they said they were coming

down right away. One lady was washing. One told me they had sickness in the family and I did not like to shut the water off." But that last bunch is pretty hard to get in, so that by the end of the month perhaps out of 9500 bills we will have about 100 to carry over to the next month. That is a small proportion, but we do not reduce it to that number except by ding-donging and keeping after them all the time. The big problem in the water works business is, "How are you going to get the money in?" We can filter water with a turbidity of 3000 and with bacteria of 25,000 and get a satisfactory water, but it is easy work compared to getting money from a few of those people who do not want to pay. Yes, Mr Hurtgen, we add the 10 per cent penalty to their next bill.

P. J. HURTGEN: I am interested in that for, commencing the first of June, we have adopted a new rule by which we are going to follow that same plan. We are going to add a 10 per cent penalty on bills that are unpaid. Our bills are due from the 1st to the 10th, and on bills not paid between those dates, 10 per cent penalty will be added. Now I have not decided on the delinquent notice, but I expect that I will send out a delinquent notice after the 10th notifying them that the penalty will be added to the following bill. We only collect twice a year. We have our system divided up into three districts and are collecting every other month in one of those districts. This rule was followed for in each district we have about 3000 consumers, and between the 1st and 10th of April, in one district out of 2800 there were probably 250 delinquents. We would send out a delinquent notice and then a final notice that we would shut the water off, and we would still have out of 3000 probably something like 200 people to shut off. So we have adopted this new rule that 10 per cent penalty will be added after the 10th of the month and the water will be shut off without further notice on the 21st. But in the meantime we will send out the delinquent notices and we believe that in that way we are going to get most of them to pay their bills. These new bills will be printed in red.

DOW R. GWINN: We did that, too, but those chronic delinquents are hard boiled and do not pay much attention to red ink.

CHESTER R. MCFARLAND: The question is whether it is just to add a penalty to an unpaid bill. We are nothing but merchants doing

business; if you are merchandising, you will give a man a discount for paying his bills promptly, but if he does not pay, you do not penalize him 10 or 15 per cent because he does not pay and I think that is a source of antagonism. I have tried both ways and I find it is better to give them a discount for paying their bills, but not to penalize them because they do not pay but induce them to pay, if they do not pay within a reasonable time, by discontinuing service. The case is the same as that of a merchant who discontinues furnishing goods if they are not paid for. A grocer will not keep on furnishing goods if you do not pay your bills. If you cannot get your money in to pay the expenses of running a plant, you will necessarily have to stop, so that forces their attention that it is just as necessary to pay their water bill as their butcher bill. I think you will get better coöperation from every customer in that way than by penalizing them. That is a suggestion I will offer. I do not consider it proper and just to penalize a customer by adding a percentage to his bill.

J. F. Willett: The Montana Public Service Commission does not allow penalizing; they say we cannot penalize the customer, but we allow 10 per cent discount up to the 10th; after the 10th they must pay the full face of the bill. After the 12th we send out delinquent notices; then if the bill is not paid, we send the shut-off notices by registered mail, because we find so many people who say they never received that notice. I have had some of them say they did not receive it where we had their signed receipt in the office, but there are very few of that kind. We send a registered notice to all shut-offs.

ARE CONSUMERS ALLOWED TO DO PLUMBING FOR THEMSELVES? IF SO, HOW IS THE DEPARTMENT OR COMPANY TO KEEP RECORDS WHERE SERVICE IS ON A FLAT RATE BASIS?

Stephen H. Taylor: At New Bedford we install the service with our own forces to the street line, and, if the customer desires, which he almost always does, we lay it inside the building. The plumber puts on a meter there and goes ahead. We are practically 100 per cent metered.

G. W. Brisbin: We furnish the service from the water main to the curb or service box, and from that point in it is taken by a plumber. The plumbing of Battle Creek is done perhaps as cheaply as any city with which I am acquainted, and more so than most of them, and we have very little difficulty. Once in a while a man does some secondary plumbing after the first installation, and does it himself, and if it is not good, we make him take it out and install it correctly or have a plumber install it correctly. We do not have any of the trouble that this question seems to call for. Perhaps that is partly because we have the installation of the service from the main to the curb box; we do not allow anybody, willingly, and very few do it anyway, to put in plumbing of any kind and I do not think it ought to be done. We had a great many frozen fixtures and a great many fixtures that were installed improperly in other directions, simply because property owners and their help and friends tried to do plumbing, so we stopped the whole business of persons doing plumbing in any way whatever. I do not think that the average city need be troubled with that sort of trouble at all, if they will install the service themselves and have a licensed plumber to do all the work, at any rate all that amounts to anything.

Henry P. Bohmann: As I interpret the question, it means how does the water company make charges for fixtures that are installed without the knowledge of the water company. I think this is a mighty big problem. I remember reading the report of a large

water works in which it prided itself that it had collected $15,000 for connections in one year that the water company did not know anything about. I think no one should do any plumbing except a licensed plumber under a permit issued by the city.

STEPHEN H. TAYLOR: At New Bedford when we were operating under the fixture rate, we sent an inspector to every house once a year to thoroughly inspect all fixtures and in that way we kept track of the fixtures in the house and checked up the leakage. We had at that time a maximum rate, and after the fixture rate amounted to $13.50 the owners could put in all the fixtures they wanted without further charge. Up to that point, however, the fixtures were kept track of by annual inspection.

THEODORE R. KENDALL: In Nyack and South Nyack, N. Y., there is only one annual inspection to determine the number of fixtures in the house and this inspection takes the form of merely questioning the housekeeper at the door. I believe that if the same type of inspection is customary in large communities, a good deal of money would be lost to a water department by having only one inspection of flat rate customers a year, and that taking the word of the consumer. There may be 100 or 1000 or 5000 fixtures put in between the annual inspections which means a material loss in revenue. Does anyone here know of any places that are inspected more than once a year as Mr. Taylor speaks of in New Bedford?

ALEX LIVEZEY: My company has some fixture rate connections. No one is supposed to do any plumbing in Newport News except a licensed plumber. We do not, therefore, allow consumers to do any plumbing. We have frequent inspections, probably twice yearly, on the few flat rates that we have. I think the solution, however, to this problem is 100 per cent meters.

CHESTER R. MCFARLAND: In Tampa we make one annual inspection in the spring of the year, about the time they begin to put on the sprinklers. We have a rule that, if we find extra fixtures installed which we do not have on the books and which have not been applied for, we charge them for the quarter we find them on and the quarter before that. If they install a fixture and have not reported it to the office and we find it in the quarter between April and July, they have

to pay for the current quarter and the back quarter. We also keep our inspectors going all the time in addition to this annual inspection; they report every house and every fixture, but if we suspect there is work being done on the houses of which we do not have records, we send a *suspicion* inspector to look it over. We have just made an inspection and have collected enough money from this annual inspection to more than pay all our inspectors for the first six months of the year. They will put on additional fixtures without reporting them and you cannot stop them. When I first investigated that matter, I found there was no law that would permit us to license plumbers unless there was an official ordinance of the City Council. The City Council would not grant that, so there was nothing for us to do but follow it up by annual inspections. We have a great many people in our country who are natural born plumbers and they work for themselves and their neighbors and friends, and we have to watch them all the time. I think there is only one remedy and that is constant inspection of the premises.

C. B. KNERR: The way we do it in the city of Bethlehem is as follows: We have six inspectors continually going around; once every two years we make a physical inspection of every house, and that means something when you have 13,000 and some odd services and about 75,000 spigots. The tenant has no right to put in spigots, but they put them in. The plumbers do so too. We have licensed plumbers, and when we find out who has put fixtures in, we have a fine of $25 and costs, and in that way we keep them in check. We have fined some tenants already $25. We have to make an example of some one. The Public Service Commission has nothing to say to us in the cities; we are our own bosses. The only solution to this is 100 per cent metered services.

MUSCOE BURNETT: The gentleman from Florida has just stated that his company was not permitted to license plumbers and require them to do all work under the Water Company's rules and regulations, unless the Common Council of his city passed an ordinance to that effect. I am interested in learning if any member present is familiar with any court decisions that have or have not held that a privately owned water plant has the right to license a plumber, and also to require the plumber to furnish a bond, other than a decision made by the Kentucky Court of Appeals in a suit in which the Water

Company of Paducah was a defendant. In Paducah the City Council passed an ordinance, carrying out a mandatory clause in the water company's franchise, giving the water company the authority to license all plumbers, and also an ordinance making it a crime for any plumber to extend or repair any pipe or fixtures connected with its mains. The Kentucky Court of Appeals held that a city owning its water plant had a right to enforce such ordinances, but that it could not delegate such power to a privately owned plant.

Our company has had little trouble with the established plumbing firms, all as a rule reporting all work done by them. We are having trouble, however, with a class of cheap mechanics attempting to do all kinds of plumbing and who are not getting permits from the water company for any of it. We are considering the advisability of again taking the problem into the courts. I should be glad to learn if any one here, representing a private water company that is requiring a bond with a license, has had its rights along these lines tested in the courts.

Dow R. Gwinn: Replying to the question whether any private water company was given permission to issue license, we never asked the permission for our company, we took it for granted that we had that power; we are running the water works business in the interest of the citizens, and in order to take care of them, there must be certain rules given for the plumbing. The city has a plumbing inspector who looks after the sanitary part, and the water company has certain rules governing the putting in of fixtures, specifying what kind of fixtures may be put in. Of course the question has been raised sometimes, on several occasions I guess, "I'm paying for this, I'll put in what I please," with emphasis. "Oh, yes, that is true, you are paying for it, but we are furnishing the water; we are on the other side of the contract, it takes two; if we have to supply you with water and take care of you, we must have rules governing how we are going to supply it and through what connections. You are allowed to use water, but we cannot give you all the water that we pump; we give you your proportion, but we must specify the size of the service pipe." A man will come in and say, "I want a 6-inch pipe." "We cannot give it to you. What do you want to do with it?" "I want it for fire protection." "We do not allow anything larger than 4 inches." "Well, I want 6." "You cannot have it." I have to explain to him that we are operating a direct pressure plant and we must fur-

nish, first of all, the public fire protection which is paramount. Another man will come in and raise the question about the kind of water closets he will put in. Our rules do not provide for flushometer closets; they have some in there, but they put them in contrary to our rules. Of course, they are supplied through a meter, but we will not supply a large pipe for a flushometer unless the other requirements are such that it makes a large pipe necessary.

The question as to our authority to license plumbers was raised some years ago and the plumbers employed a lawyer, but they did not have enough confidence in their case to take it into court. Our attorneys held that we were right and the others were afraid to go in and try it out, so we required licenses. Before we issue the license, we require a bond of $1000 that they will do the work in accordance with the rules of the water works company. Of course that is not all there is to it, that is just the beginning; the troubles come afterwards; but it saves us a lot of trouble with the plumbers when we have got a $1000 bond on file. We never have had occasion so far to collect on that $1000 bond, but it has a good moral effect on the plumber. He is a little more careful than he would otherwise be. Coming to the question about putting in the pipe, if the plumber says, "I can put in anything I please," we say, "You cannot put in black pipe, if you do we will not turn the water on for you; it must be galvanized or lead pipe," because we do not want our customers served with rusty water.

Chester R. McFarland: Suppose the plumber does not comply with the rules, puts in fixtures and does not report them; can you enforce your remedy on those bonds?

Dow R. Gwinn: I think we could, if necessary.

Chester R. McFarland: I doubt it.

G. W. Brisbin: A franchise for a water works is a contract between the city and the company, and I think it depends entirely on what that franchise says, how far you can go with plumbing regulations or anything of that kind.

Muscoe Burnett: In Kentucky the courts have held differently.

G. W. Brisbin: That it depends on the franchise?

Muscoe Burnett: No, sir; the courts have held that the city has no right to delegate that power to a private company.

Charles B. Yobst: At Fort Wayne, Indiana, we have a plumbing ordinance passed by the Council and we hold the plumber with that.

Dow R. Gwinn: Your plumber's ordinance is different from ours.

Charles B. Yobst: The Council issues all ordinances for plumbing, sewerage and everything else.

Dow R. Gwinn: We have no franchise. We are doing business on an indeterminate permit under the Indiana statutes.

WHAT PROGRESS IS BEING MADE IN THE ADOPTION OF THE STANDARD THREAD FOR FIRE HYDRANT NOZZLES?

Charles B. Yobst: As I understand it now, we have what we call a national standard of $7\frac{1}{2}$ threads to the inch which is adopted by all hydrant manufacturers and called the national standard.

Dow R. Gwinn: Yes. Every city in Indiana now, with the exception of Indianapolis, has the standard nozzle. We held out for years because our nozzles were so close to the standard that a standard hose could be attached to the hydrant, but for the sake of uniformity we agreed with the inspection bureau to have them changed. We changed those nozzles on our hydrants and it was a very simple matter; the inspection bureau sent their men out with the adapters, a little device for cutting the nozzles to the standard, and he stayed with our men for one day, after that the men did it without any help. It took 104 hours for two men with a Ford to change 1245 hydrants. One man was paid 40 cents an hour and the other 45, and we charged 50 cents an hour for the use of the Ford. There are two nozzles to each hydrant. The average cost per hydrant was 13.1 cents. That put us in line with every city in the state except Indianapolis, so that if we have a serious fire and call on Fort Wayne or Vincennes or some of the other towns to come to help us out, their hose will fit our hydrants. It is worth while.

Answering Mr. Craig's question, the city paid for changing the hose threads. This same man instructed the city how to change the hose threads on the city hose and the city firemen did the work themselves, and then they went to the private plants that have fire hose and hydrants and did the same for them, and we took care of the private hydrants. The cost of changing hose threads would be less than on hydrant nipples, as it would all be done at the engine houses.

Isaac S. Walker: What about changing the threads on the steamer connections? That is a rather difficult procedure; 4 threads to the inch is the underwriter's standard, if I recollect correctly.

Dow R. Gwinn: I did not understand that there was a standard for the steamers.

Isaac W. Walker: Four threads per inch, as I understand. It is a comparatively easy matter to change the 2½ inch nozzles. We changed them at Greencastle. We had 8 threads per inch on the hydrant and they were recut to the underwriter's standard of 7½.

Dow R. Gwinn: Our fire department took two 2½ inch lines from the hydrant and connected up on each side of the steamer; not a Siamese connection, we take two 2½ inch lines and connect to the steamer.

(The National Standard included 2½-inch, 3-inch, 3½-inch and 4½-inch nozzles. The 4½-inch with 4 threads per inch. No tool has been produced as yet for changing the steamer or 4½-inch nozzles and there is no record of any changes to Standard of such nozzles. Tools for recutting 2½-inch nozzle threads to Standard when they are near enough for the purpose are on the market, made among others by the Greenfield Tap and Die Corporation, Greenfield, Mass. The set includes several tools, for cutting male and female threads and for expanding nipples that are slightly under size for recutting.—*Editor.*)

Isaac S. Walker: The inspection bureau just made an inspection at their plant in Vincennes and they recommended the adoption of the standard thread 7½ on 2½ inch outlets and 4 on the steamer outlets. I think we only have a few steamer outlets there and I think they are about 7 threads per inch. All our threads in Chester are 7 per inch; it is a pretty difficult proposition to get down to 4 per inch on those large outlets.

W. C. Hopper: I will say that the inspection bureau in Ohio just got through with the biggest part of Ohio; they are going back towards Columbus, and they tell me that when they get on that return trip, Ohio will be practically standardized.

PAINTING FIRE HYDRANTS: BEST COLOR FROM FIREMAN'S STANDPOINT AND FOR PROTECTION OF HYDRANT

Charles B. Yobst: We selected red with a white enamel top.

James E. Gibson: At Charleston we live in a salt atmosphere and paint is rather a hard article to deal with, particularly on iron, but the custom has been to paint red. Recently I began a study of the matter and in one of the periodicals, the Journal of the New England Water Works Association, I read a paper by Carlton E. Davis, of Philadelphia, giving the results of some tests he had made on various colors for hydrants, and finally stating that he had adopted yellow as the most distinctive color both by daylight and artificial light. With this information, I recommended to our Commission that we paint our hydrants yellow with a black band near the ground to take care of the discoloration due to splattering of dirt and mud during rainfall. This recommendation was adopted. We have painted, therefore, all of our hydrants an orange yellow in color and we find them to be very distinctive. One of our Councilmen, sometime after we had a number of hydrants painted in the business section, stopped me and wanted to know "Who ever heard of painting a fire hydrant any other color but red." My reply was "You will note in Charleston we have painted them yellow." He stated that he had never heard of yellow being the proper color for a fire hydrant, but he said, "To tell you the truth, I never knew we had so many fire hydrants in Charleston." One of our men, while painting a hydrant, was closely observed by one of our citizens and after the latter had watched the painter for sometime he turned away in disgust and said in an undertone, "When did our mayor turn Orangeman?" Yellow is a distinctive color, and as you drive around the city after dark in your automobile you can observe the yellow fire hydrant three or four squares ahead of you without any difficulty, and they stand out against the dark background. We had hoped that this distinctive color would reduce accidents from automobiles and joyriders, but we have about concluded that when a man goes out joyriding such a little thing as a yellow hydrant will not stop him.

ALEXANDER MILNE: How long does it stand up?

JAMES E. GIBSON: I have not had enough experience to answer that question.

ALEXANDER MILNE: Heretofore we have been using green throughout Canada; once in a while you will find a yellow one. Two years ago at the request of the fire chief, we painted red enamel by using a Chinese vermilion enamel with a yellow ground color to bring it out. After two years those hydrants looked like blazes, the enamel does not preserve them, it breaks off and even the lead paint does not stand. After a lot of experimental work I found that by using a standard green with 10 per cent graphite in the mixture, you get no condensation sweating at all, there is no discoloration; the hydrant will stand there five or six years without losing its color. True, you do not see them so well at night, but the firemen are supposed to know where every hydrant is, and it appears to me that the hydrant should be painted with the best preservative for the hydrant without particular regard to display. The white caps, I do not think much of, they look too much like Ku Klux outfits; my choice is the green with the graphite mixture.

G. W. BRISBIN: At Battle Creek for a great many years we painted our hydrants green, and that is the color that is best from the aesthetic standpoint. There is no question that it is a mar to the landscape to have a red hydrant, almost as much of an incongruity as shaking a red rag at a bull. At first the department did not like the green and they insisted on having the hydrant painted red, and while I did not like the idea, we conformed to their views because they are the ones that have to use them. I do not think they can stop to look at a blueprint when they go to a fire to see where the hydrant is—they are not allowed fifteen minutes to get ready.

W. E. MILLER: They are supposed to know where it is.

ISAAC S. WALKER: I might add just one word to Mr. Lamey's remarks on one point which influenced us somewhat in deciding to try out the yellow color for our hydrants in Chester. Quite recently the Pennsylvania Railroad adopted this color as the standard for all the signals on their entire system, tests, I am informed, having proved that this color may be more readily observed, both by day and by night, than any other color.

It was therefore believed worth while to try out this color on our fire hydrants, as prominence is desirable in order that firemen may readily find them at night. From this standpoint the color green is unsatisfactory when hydrants are located in grass plots and near trees or shrubbery. We selected the same shade, a brilliant yellow, used by the Pennsylvania Railroad. The color used by Mr. Davis in Philadelphia was more on the orange hue, or "pumpkin" color. The painting was done about six months ago, has held up well, and has caused no especially adverse comment.

R. H. Starr: As regards the painting of hydrants a yellow color, has any consideration been taken of that color in connection with the northern countries where the snow gets up two and three feet higher than the hydrants. How does yellow show on a snow background?

(Answer—Very good.)

If yellow is then such a good color why not go one step further and use a yellow luminous paint which should make the hydrant more prominent at night. Such a paint is made by an English firm and carried in stock in Montreal.

J. A. Jensen: The color used on hydrants does not make any difference so far as protection is concerned. Red paint has been adopted in many places to make the hydrant conspicuous, but breakages are the results of accidents and placement of hydrants, in which color plays no part. To make a hydrant conspicuous it is important to get a permanent color if possible. Red and yellow both fade to a dirty white with variations. Green is the most desirable and durable color, especially in residential sections. Painted green with a red or yellow cap or dome the hydrant can be made prominent or conspicuous with as little maintenance as any painting scheme.

Stephen H. Taylor: At New Bedford we stick to the old dark green, almost black, but the fire chief does like to have the cap painted white to distinguish them at night. We have stuck to that color a long time, the only change being the addition of the white cap. One of our neighboring towns uses red and paints them every year, but the paint does not stand up at all well.

J. M. Diven: Almost any paint will preserve iron, fire hydrants as well as other iron surfaces, and a hydrant that is kept properly painted for display purposes will always be well covered and so

protected from rust. Fire hydrants are first of all for use, not for ornament and the aesthetic aspect should not interfere with the utility.

It is all well enough to say that the firemen should know where the hydrant is located, but with 500 or more hydrants in a city is not that too much to ask of a fireman? It would be ideal if the hydrants could all be located on the same corner, say all in a city on the north west corner of the street intersection, a fireman would then know just where to find them. But this would not help for hydrants in the middle of blocks or other points than street intersections. Getting to a hydrant and connecting up is a matter of seconds or even less, not of minutes. To stop a heavy piece of fire apparatus near where a hydrant is located, locate it exactly, start up again, maybe have to back or cross a street, takes precious time. If the hydrant can be seen by the driver, even approaching at full speed, so he can make a stop at the exact location it will save these valuable moments.

On a recent visit to Philadelphia I noticed that the yellow painted hydrants described by Mr. Davis looked dingy and were not easily seen in daylight, so I am doubtful whether that is going to prove the ideal color. I am inclined to think we have further to go.

I have used aluminum bronze and found it satisfactory from most points of view. It was easily seen both night and day, lasted well and was a good protection for iron. It was high in first cost, but outlasted anything I ever used before or since. These hydrants were painted over the old red without retouching or attempting to make a good ground. Probably a little more pains in putting on a good and light colored ground, would have improved them both in appearance and lasting quality.

To the speaker green seems the least suitable color. It is not distinctive in any situation, with any background and is not easily seen at night. It is especially hard to see, night or day, on residence streets where the hydrants are usually placed in the parking between the sidewalk and curb, where they blend with the green grass and are not conspicuous at night or day.

One other thought comes up in this connection. When the color is finally determined on it should be "patent righted," an ordinance should be passed prohibiting the use of that particular color for lamp posts, signs or other structures that might be confused with the hydrant. The hydrants should have their own peculiar color and mark so as to be quickly and easily seen, located in a hurry and confusion, as is usual when answering a fire alarm.

FIRE PROTECTION SERVICE OF THE WATER DEPARTMENT: SHOULD IT BE PAID FROM WATER RATES OR GENERAL TAX FUND?

Dow R. Gwinn: That is a question that the municipal people are all interested in. It does not make much difference to us private company men.

Lyman P. Hapgood: From the general tax fund. In fixing a water rate, whether it be a "flat" or a "meter" rate, it is contemplated that there will be used a certain quantity of water in a given period of time, and that the rate so fixed will produce revenue in a sufficient amount at least to meet the cost of production and distribution, maintenance, interest, sinking fund and depreciation.

In the matter of public fire protection, the quantity of water actually used has little, if any, part in fixing the proper charge therefor. The quantity so used often amounts to less than 0.5 per cent of the annual pumpage. But a plentiful supply must be always ready and available for instant use without notice.

To make such ready-to-serve conditions possible, special apparatus, as hydrants and reservoirs, are installed, and pipe sizes, pump sizes and water supply and filtration must be increased over and above those required for supplying the consumer with his requirements for domestic, commercial and manufacturing use. It is estimated that from 20 to 40 per cent of the total capital outlay in a water works system is for fire protection alone.

When the charge for fire protection is worked into the consumers water rate then he is obliged to pay not only for the water he has used and expects to pay for, but, in addition, he shoulders a burden rightfully belonging to another, who thus escapes that burden entirely, the non-resident property owner.

When the charge for public fire protection is placed in the general tax levy, where it justly belongs, every property owner, both resident and non-resident, especially the non-resident property owner, contributes his own fair share of the cost and upkeep of that fire

protection service which is one of the things that makes his property valuable and upon which he bases his rate for rents.

But when this charge is paid by the water consumer then the non-resident property owner, the value of whose property is greatly enhanced by the protection afforded, takes absolutely no part in its support though receiving its benefit.

Consequently, the only fair way to charge for public fire protection is by putting the charge into the general tax levy that all, benefiting by the service, may share its costs, and also that the water consumer's rate may be lower by eliminating that charge from them.

Dow R. Gwinn: This question is open for discussion. Perhaps you may agree with Mr. Hapgood; it sounds like good common sense to me.

P. J. Hurtgen: In the city of Kenosha our operating revenue was approximately $135,000 per year, and the matter of fire protection is fixed by the Railroad Commission. Last year we charged a part of the fire protection off in general taxes and the basis on which they arrive at the proper amount is something similar to what you have just read. That part of the system that is in excess of what is required to furnish water for other than fire protection. The way it works out in our city, with a population of about 45,000, is as follows: We have three pumping units and our daily consumption averages 5,000,000 gallons. We have three pumping units with a capacity of 6,000,000 gallons each, and, during the peak load, we operate two of the pumps; probably one only about an hour or two per day and some days we operate only one pump. Therefore, practically a third of our entire pumping system can be charged to fire protection, because we have that one pump in reserve all the time; and that ratio applies practically throughout the entire system with the increased size of mains and the increased pumping capacity. While the Railroad Commission allowed us $42,000 it should have been about $45,000, namely one-third of our operating cost which was approximately $135,000.

It amounts to about 33 per cent and I think that is a just charge to the city at large and should not be borne by the individual consumers. Now the Railroad Commission of Wisconsin have made some calculations by which they claim that in cities of about 60,000 inhabitants and below, about a dollar per capita per year is some-

where near the proper charge for fire protection, and that is about the way it works out in our city, our population being about 45,000.

In answer to Mr. Gwinn's question, we did take into consideration the larger sized mains necessary, for we could get along with smaller mains if we were not furnishing fire protection.

We took into consideration the increased size of the mains, pumping units and also the increased number of filter beds.

ALEXANDER MILNE: A few years ago the question came up before the convention and I kept some notes of the proceedings at that time and looked them over ten days ago with a view of speaking on this topic after our Chairman suggested it. I think we found at that time that, taking the average water works plant of the United States and Canada, the estimated cost for water supply on the total capitalization of the plants on the continent at that time was about 47 per cent for fire protection purposes over the capacity and equipment necessary for domestic use. It strikes me that it would be a rather hard matter for the majority of the municipal plants to induce your city councils to levy a rate for fire hazard, sufficient to produce 47 per cent of your total revenue. We found it so in our city. We finally compelled the city council to levy a hydrant levy charge of $40 per hydrant and we made them pay it. Recently we got into another fight on the same subject and the city revenues were rather depleted and ours were increased. Our financial situation was in pretty good shape and they cut our hydrant rental to $20 a hydrant, which is too small. I had very hard work to convince the members of the Board who thought we should collect that entire charge in water rents; our consumers were well satisfied with their rates and were paying them quite promptly, but after considerable argument I persuaded the city council that the fire protection charge should be collected from the general tax rates of the community by a levy assessed as an item on the tax roll for fire protection, whereby every individual property pays exactly in proportion to its assessment, and this fire protection benefit is supposedly in proportion to that assessment. Take two neighbors on the same street: one has a $25,000 house and the one next door has a $3000 house; each is paying exactly in proportion to his assessed value and the protection he gets from the fire department. I think it is the only way to levy that fire protection rate.

Henry P. Bohmann: I just want to confirm what the previous speaker said about the city council not permitting such a rate to go into effect. In the city of Milwaukee we at one time charged an annual hydrant rental of $3 per hydrant and it was never paid. The rate was later raised to $5 and occasionally paid. Now we have made it $10 and it is always paid. The charge of $10 just about pays for the hydrant inspection and maintenance. As to making a charge based on the excess cost due to increased size of mains to take care of fire protection, I think is a very debatable question. In the case of a large and growing city, the distribution mains should be large enough to take care of this growth, otherwise you would be digging up and relaying your pipes all the time; therefore, the size of the pipes you lay in excess of the immediate demands to take care of future growth should at all times take care of your fire protection which does not amount to anywhere near 40 per cent; in small towns, however, a water works is built primarily for fire protection, but in large cities, where every lot is built up and you have to build for future growth, you would be forever digging up your pavements, unless future growth is anticipated. We feel that the system we lay will take care of the future growth of the city even though a certain district may today have only small residences or large apartment buildings. We never notice even the largest fire at the pumping station; so when you speak about charging 40 or 50 per cent of your investment to fire protection, it may be true of small towns, but not in the case of a large city.

Alexander Milne: Replying to the speaker on that topic, the figure I gave of 47 per cent was the general average of all water works plants on the continent.

Chester R. McFarland: This question seems to me out of place in this meeting. In the first place, the superintendents are unable to fix this rate. This is a very abstruse problem. There are three classes of people in each city; first, the consumer; second, the property-holder who has an improved property that has to be protected from fire loss; third, the person who owns vacant property and has no buildings to protect; the only advantage he gets from the water system is that he has a water main laid in front of the premises which makes it more valuable, in the same way that a business property is valued by the number of people who pass it during the business

hours of a single day; his property is made more marketable. The question has been raised as to the proper proportion to charge for fire protection. In the first place, you lay a main in a street; it is ample to-day to provide fire protection and to provide the public with all the water they want to consume; but, in five years from now, if that city is prosperous, that section will be built up and the consumption will grow to such an extent that the main that provided fire protection and water supply will not provide sufficient water for domestic purposes. Would it not have been fair to have charged the extra size of that main up to the public to protect their property? So it seems to me that this is a question with so many ramifications and so many details that it will take a thorough study of the whole subject to enable anything to be put before this convention that would be reliable, something on which you may base your report.

W. C. Brockway: Relative to fire protection service and hydrant rentals, the city plant at Duluth charges $50 a hydrant. This amounts to about $55,000 a year. The actual cost, however, amounts to approximately $110,000 a year for fire protection service, according to manager D. A. Reed.

Since 1918, however, the city has failed to pay the hydrant rentals. The Water Department does not pay taxes. It is informally understood by both the city and the Water Department that the hydrant rental charge amounts to the difference between the cost of rendering fire protection service and the amount of the local taxes. In Duluth a difference of opinion exists among the officials and interested citizens, as to whether the water department should pay taxes, and what taxes should be included.

Dow R. Gwinn: In our city, the plant is privately owned, our gross earnings last year were $334,000. Our taxes of all kinds, including federal taxes, were $67,000 or 20 per cent of our gross earnings. The city paid $60,000 for public fire protection, but they also paid for the water used in the schools and public buildings, so that practically the amount paid by the city just about offset the taxes.

James E. Gibson: In Charleston, South Carolina, we are municipally owned. We pay no county, state or federal taxes. The city pays to the Commission $44,000 per year for the first 600 hydrants, and $25 per hydrant per year for all hydrants in excess of 600. The

payment of $44,000 annually includes an allotment of 300,000 gallons of water per day for municipal purposes. This is where we get our fingers pinched, for instead of taking 300,000 gallons of water per day the city takes from 900,000 to 1,000,000 gallons and as there is no appropriation for this excess it is up to us by inspection and co-operation with the other city departments to keep this surplus water down to a minimum. If we had to pay taxes as Mr. Gwinn, I am afraid it would be a losing proposition. The gross revenue for water last year was $390,000. In addition to this revenue there is $30,000 revenue obtained from interest on the investment of surplus funds in the plant. The department pays all interest, depreciation, maintenance and sinking fund on the investment of $1,500,000 bonds, with which the plant was purchased in 1917. All monies are retained in our treasury and all improvements to date have been made from a surplus income. During the six years of municipal operation we have added something like $990,000 to the value of the plant, all of which, as before stated, has been paid out of surplus with the exception of a loan made by the National Government during the war period. This loan now amounts to $250,000, so while we do not pay taxes we are carrying the burden of the waterworks, and we are able to make all improvements without going before the people for bond issue.

George E. Chambers: At Buffalo we get $15 per hydrant per year for about 6000 hydrants which we maintain; we maintain the hydrants and furnish the water to that amount.

J. M. Diven: It is obviously unfair that a person with a property valued at $1000 and having a single faucet should pay as much for water, the rate including the fire protection water cost, as a large warehouse pays, which with its contents is valued at many thousand dollars and has a single faucet. The warehouse gets fire protection on a large property value for which the owner of the small house helps to pay.

How would the people of a city look at it, if the appropriation for the maintenance of the fire department, engine houses, apparatus, firemen, etc., were separated from the general tax and charged at a price per front foot? Yet this is exactly what many cities, where water rates are based on frontage, are doing. The water service for fire protection is just as much of the cost of maintaining the fire department as the payroll of the firemen.

DIRECT FIRE PRESSURE VS. PORTABLE PUMPING APPARATUS

Dow R. Gwinn: This question to my mind is one of the most important questions we have before us today. About a year ago Mr. Charles Henderson of Davenport, Iowa, one of the past Presidents of this Association, presented a paper which was published in the proceedings for July, 1922. He went into the matter very thoroughly by corresponding with the different cities to find out how many carried fire pressure. He found that the increase of pressure ranges from 4 to 55 pounds; the average is 24 pounds. In the large cities, such as New York, Philadelphia and Baltimore, high pressure hydrants, supplied by separate pumps, take care of fire supplies. The consensus of opinion seemed to be that in the larger cities they should not raise the fire pressure as it would be taking too many chances of bursting some of the mains and that it would be better to depend upon the ordinary domestic pressure, assuming it was 45, 50 or 60 pounds. He states that ordinarily firemen do not require more than 40 to 45 pounds pressure at the base of the nozzle. Large fires require more pressure than any water works can safely carry. The mistake, as I see it, has been made in many places of trying to get along with a few hydrants by using long lines of hose. That is very expensive and the friction loss is so great that much of the pressure is lost before it reaches the nozzle.

The city should be provided with pumpers to take care of any additional fire pressure that may be necessary. In a talk with one of the officials of the Board of Fire Underwriters he expressed the opinion that, in a city of 50,000 or larger, pumpers or fire engines should be provided to take care of the pipes.

Thomas Healy: At Davenport we raise the pressure on the upper level. We carry a pressure of 45 pounds and at time of fire we increase it to 70, and on the lower level we have a domestic pressure of 65 and raise it to 110. Every time we make those changes, we burst service pipes, the plumbing in houses, and often break mains. If you break a main at the time of fire, you haven't much fire pressure

and it is a very dangerous proposition. The simple remedy is to lay mains larger and provide a distribution system to take care of fire service. We have a reservoir at which the static pressure on the lower level is 65 pounds from our reservoir head. If we did not have to provide fire protection, we could lay smaller, lighter mains and it would not cost so much to construct the plant or so much for upkeep.

Stephen H. Taylor: At the convention of the New England Water Works Association last fall a paper was read by one of the National Board of Underwriters and his summing up was, as I recollect it, that the water works should not be required to raise the pressure, but portable pumping apparatus should be provided for the reasons outlined in the paper you have just read, that it entailed an unnecessarily heavy expenditure for larger mains, that the same expenditure in portable pumps would do a great deal more good. In New Bedford we have a pressure varying from 14 on the hill to 90 pounds at the water front. I notice in every case, even if the fire is down at the water front, the fire department connect their pumpers, and it seems from the experience in our locality that the pumpers are less expensive than the extra expenditure in the water system for larger and heavier pipes.

Alexander Milne: I do not think there is a great deal to debate on this question looking at it from the ordinary water works point of view. We have had several papers recently. Mr. Jensen's paper was a very good one, I think the best I have heard, as between the direct fire pressure and the pumper service, given this forenoon across the river at Windsor, at the annual meeting of the Canadian Section. By the way, we have got 200 members now over there and we are holding two meetings a year. I am only sorry that more of our members were not over there to hear what we were doing. Mr. Jensen of Minneapolis gave us a most excellent paper on this subject of pressure, which will be published in the engineering press and in the Journal of the association. I recommend that you read that paper; you will find it the best paper on this topic.

G. W. Brisbin: We carry unusual pressure in Monroe, Mich.; we carry from 60 to 90 pounds pressure ordinarily in all except a very small portion of the city, which gets about half the pressure; in other words, it is about a hundred feet above the level of the business portion

of the city. We do not find any trouble from the excessive pressure as some people would call it, because it serves a great many purposes. For instance, we have a machine for cleaning sewers; that machine becomes stalled once in a while; in our neighborhood we have only half the pressure carried by most of the city, and unless we had a direct pressure system, we could not operate that machine successfully in a great many cases. People like the high pressure because the sprinkling is better. I do not think there is much danger of the bursting of pipes, because we have two pumps at our well stations and they run as high as 120 and even 122 pounds pressure and have never burst a pipe as far as I know. We use extra heavy lead pipe in the street for small services, and galvanized standard pipe in the buildings and yards. It seems to me that a water pressure should give a pressure that will answer the purpose best, and you cannot get any more pressure for that because no city, or at least almost no city, is on a dead level or nearly dead level. In spite of all the protest made against high pressure and against the use of pumping engines, I think it would be better to increase the standard domestic pressure as it is ordinarily called rather than decrease it, and while we have two fire engines, we had none for a considerable time and the chief of our fire department said he would not want a bit more pressure than he has in the lower part of the city for any ordinary fire. When it comes to a fire in an eight or ten story building there must be more pressure, and there we have pumping engines; our neighbors think we are all right, that we have the best end of the matter of pressure, and I believe they are pretty near right. While it is expensive, it is a really good thing to be able to furnish people with water at a good strong pressure as we have in our city. We use class B pipe.

Isaac W. Walker: I agree with the last speaker that a good pressure is certainly to be desired in a water works distribution system, but there are limits beyond which it is unreasonable and unnecessary to go. I should say an average pressure of about 70 pounds is to be considered excellent and generally satisfactory for all usual purposes, other than fire protection for the higher buildings.

The dependence upon increasing the pressure on the system to a 100 or more pounds for fire fighting purposes, is unsatisfactory, and I believe it is becoming pretty generally recognized. Many comparatively small towns now have their pumping apparatus. In an Indiana city, which one of our plants serves, a town of about 18,000,

it was the practice up to a short time ago to require us to cut out our standpipe and raise the pressure by direct pumping, to about 105 pounds when alarms of fire were sounded. Following the recommendation of the Insurance Inspection Bureau, and the demands of several Civic Associations, they recently purchased two pumpers, which eliminates the necessity for increasing pressures. Such increases are the cause of leaks in the street mains, in service pipes and house boilers.

Where direct fire pressure is used, the size and condition of the distribution system is a factor. A direct pressure of say 100 pounds may be satisfactory and give good service in a comparatively new piping system, of adequate size pipes, whereas the same pressure, on an older system with pipes badly tuberculated, and of small sizes, would be inadequate for fire purposes.

When pumping apparatus is used, the question of whether the pressure on the hydrant is 50 or 100 pounds is, I believe, of no moment. Up to a certain point the pressure on the hydrant, of course, reduces the amount of work to be done by the pumper. But the pumper should be of adequate capacity to deliver its quota of satisfactory fire streams under all pressure conditions, so that it is the job of the water works man to see that there is sufficient pressure available to deliver the required amount of water through the hydrant to the pump. Whether this pressure is 10 or 100 pounds is of no consequence, as long as the water, in sufficient amount, is there.

George H. Chambers: At Buffalo we are laying a new high pressure line in the business portion of the city at an expense of $200,000 and will furnish a pressure of about 250 pounds at times.

James E. Gibson: I think the damage occurs at the close of fire rather than at the beginning. Your engineer, upon receipt of the fire alarm, shuts off the stand pipe and raises the pressure. He gets the machinery and column of water moving at a pretty good rate of speed during the interval of fighting the fire and toward the end the fire marshal decides that he has got the fire under control and begins to order streams shut off. The rate of shutting off the streams depends somewhat upon the training and experience of the fire department, but usually without any sense of proportion or rate of speed that the water is being delivered, and the first knowledge that the pumping station engineer has of this condition is that his pumps are

stalled due to excessive pressure and this is when the damage is done to pumps and piping.

Charleston is situated on a peninsula, the average elevation probably does not exceed 15 feet above mean tide. Our pumping station is located some 14 miles from the center of distribution and the greatest elevation within forty miles would probably not exceed 50 feet, so that we are compelled to use the direct or Holly system. We aim to carry from 35 to 40 pounds on the street mains at all times, and, therefore, the fire department never responds to a fire call without carrying a pumper. The entire question, in our opinion, is one of economy, and certainly with the improvements in the fire engine, gasoline driven engines and pumpers the economy is on the side of the pumper, for by its use the investment on mains may be reduced and the damage and liability of damage due to the increasing of the pressure on the pumping system is entirely eliminated, as the fire chief has all the pumping apparatus under his direct supervision and nothing that he can do with a pumper will, under ordinary circumstances, have any effect upon the pressure in the distribution system.

Dow R. Gwinn: We pump against about 70 pounds ordinarily, and when the fire bell rings we raise it to 125, and in these days of motor equipment, it does not take the department long to get to the fire. They want the pressure about day before yesterday and we have to hustle to get it up. The worst feature is the effect on private consumers when supplied by meters. We are 98.7 per cent metered, and when we have had the fire pressure on a considerable length of time, during that month the water bills will be considerably higher, due to the fact that water closets which are adjusted to the domestic pressure, start running; so it is bad for private consumers.

EFFECT ON PIPES OF VARIOUS SOLUTIONS USED TO CLEAN WATER SERVICES: OTHER METHODS OF CLEARING CLOGGED WATER SERVICE PIPES

No member present had had any experience with any solution for cleaning service pipes. Mr. Dow R. Gwinn stated that he used a stiff wire to loosen deposits. Mr. Charles B. Yobst used a force pump and got good results, he did not dig up at the main, but pumped from the meter connection. Asked if the force pump would clear lime deposits, Mr. Yobst stated that the water he was supplying was soft and the deposits largely vegetable. He also said that in lead pipe the lime deposits were not hard and were easily forced back into the mains.

Joseph A. Hoy: In Worcester we use cement lined pipe for houses and other purposes up to $1\frac{1}{4}$-inch pipe, all the pipe lined by our own men. The pipe itself practically never shows any corrosion. Corrosion shows at tees, inside wall and at gooseneck and corporation at main. On relieving of pressure we run $\frac{1}{8}$-inch gas pipe rods out to the gooseneck, cleaning the service thoroughly, should there be corrosion at any couplings. If we do not get satisfactory pressure then, we take a small wad of toilet paper inserting it into the service pipe, and then attach a Blake & Knowles force pump forcing the wad of paper through the service until we have pressure on the pump of at least 5 or more pounds more than the pressure on the main at that point. When we have the pressure on the pump at the point that we want to force the wad through the corporation stop, a man will open the stop at the main and with the wad of paper and the pressure up to the stop at main it requires very little pumping to force the wad through the corporation cock, where it will dissolve in the main. After that is done owners have an ample supply at meters for a number of years again. We have been cleaning service pipes for a number of years in this way with perfect results.

Dow R. Gwinn: Answering the question as to the remedy, put in a new service and use genuine wrought iron pipe of some kind, but do not use steel pipe.

CHECK VALVES ON SERVICES: LIABILITY FOR DAMAGES TO HOUSE BOILERS CAUSED BY THEIR USE AND ADVISABILITY OF USING THEM. DAMAGES TO METERS FROM HOT WATER WHEN NO CHECK VALVE IS INSTALLED

Alexander Milne: We put a check valve on every service where there is a hot water connection, to protect the meter. In twenty years experience I have had no trouble with hot water boilers. The water is quite hard. We have had no explosions. If we shut the water off, we notify the householder or consumer, if it is a commercial consumer or manufacturing plant, to protect his boiler plant while we have the water shut off; we tell him of the probable duration of the shut-off, and in twenty years we have had no boiler trouble. We take the trouble to notify no matter what time of day or night water is turned off. If it is a commercial plant or steam boiler, there is always someone in charge. In the case of a boiler or a steam plant, where they are running steam pressures, we require relief valves.

Frank Lamey: We had one experience of check and relief valves at Chester, Pa., at the plant of the American Visco Company. They are in a suburb of Chester, a model village, and we thought that would be a good place to try out our installation of check valves, so we put a check valve on each property built in that model village, and shortly after blew up two tanks. The reliefs did not work. We took some of them off and took them to the pumping station and tested them out, put pressure on them, and probably once in ten tests the checks released at the proper pressure. We became afraid of them and we have very little trouble with hot water since discontinuing them. Once in a while we have a meter burned out with hot water and we simply repair the meter and bill the tenant or the proper person for the repairs to the meter.

William R. Young: We have never used check valves in Minneapolis, but in one case a few years ago, there was a cement factory that did. After getting several bills from me for meter repairs, they put a check valve on their plant, and about the same winter an attorney

called on me and asked why we put the check valve on, as the water had blown up and killed a man, and we would be subject to damages on account of the loss of life. I immediately asked him if he would show any information he had from the Water Department that it was necessary to put a check valve on that way, as we never gave any orders to put a check valve on, because we were very much afraid of them. He said it had been necessary for them to pay for repairs on hot water injured meter discs for a number of months. I told him the only way I could see to get rid of the cost of hot water injured discs would be putting in a larger pipe from the meter to the water tank, and they would get away from the hot water on the disc. We never recommended a check valve to anybody, and would not on that occasion, and my suggestion would be to put more pipes, even if coil pipes were used, between the meter and the hot water pipes, and main pipes, and get more water there, and I do not think you would have any trouble with the discs burning out.

Dow R. Gwinn: I do not want to take chances.

James E. Gibson: My experience has been that there are usually enough leaks to take care of the excessive pressure. I lived in one of the suburban towns of Philadelphia for a number of years where I had a check valve on my service pipe, and a spring relief valve on the hot water boiler. The only objection I found was that at times, particularly on wash days, you might occasionally get hot water from the cold water spigot, and I have found the relief valve popping, discharging small quantities of water on the floor. A good quality spring relief valve with a metal seat, I think, gives little trouble, especially if it is set near the main pressure so that it will pop occasionally. This relief valve should be probably of not less then $\frac{3}{4}$-inch size.

At present we do not have much trouble from the hot water backing into the meters, but when it does we bill the consumer for the cost of repairs. At the first instance of trouble we do not press the bill, but if the trouble occurs a second time we insist upon the bill being paid or otherwise we will discontinue the service. At the same time we insist upon a check valve being put in with a relief valve to prevent future trouble. We have had no difficulty from the check valves, but we did have one experience due to a break in the main; a hot water boiler collapsed due to vaccum. When the water was turned on again the boiler resumed its former shape and as it

showed no break or leakage the party made no claim. In another case, similar to this, the boiler did not go back in the former shape, and the Water Company (then privately owned) bore a portion of the cost of repairs.

Isaac S. Walker asked if any of the members who had installed check valves had had any trouble with chattering in the valves, stating that at Chester, Pa., they had had some such trouble.

Mr. Gwinn and Mr. Gibson said they had never heard of chattering check valves, but had had trouble from that source with water meters. A member stated that he had had trouble with chattering when using upright checks, but none with swing checks.

Stephen H. Taylor: It seems to me it all depends on getting a good relief valve. In New Bedford our rules call for relief and check valves in every installation. We have had some experience with collapsed boilers, but I think we have had more trouble from lack of check valves than because of them. The whole question is to get a reliable relief valve.

Chetwood Smith: I have seen over thirty-five explosions resulting from over heating water, due to either check valves or stoppages, such as the valve being shut off between the range boiler and the service main. The force of those explosions no one can realize who has not seen them. A 30-gallon boiler raised to a temperature of 290 degrees has as much energy, as $1\frac{1}{2}$ pounds of nitroglycerine when the explosion occurs, and I think very few people realize the force of the energy they are storing up. If it were not for water closet tanks and the fact that fortunately those water closet tank valves are so light they often cause trouble and complaint, the number of explosions would be a hundred times what they are today.

Dow R. Gwinn: You are right.

Alexander Milne: I am free to admit that where the water is shut off without giving notice to the consumer, there may be trouble, but why should that be done? Except where your main breaks, there is no occasion to shut the water off without notifying the consumer. With a reasonably well equipped relief valve, your condition is taken care of entirely. During the last winter in one of our club

houses, we had a high pressure heating system, which was put on meter last fall for the first time, and inside of one month the discs and gears of the meter were burned out five times. I put a check valve on and three days after the check valve was put on my meter inspector, who happened to belong to the club, went in and looked at the meter and it was not going; it was burned out again; the check valve did not hold. So then I said "We will put a relief valve on," and I ordered one from a firm with a Canadian Agency, made for an 85-pound blowoff, an 1¼-inch one. Two days afterwards, the meter was still burned out. The inspector came over and told me. I said, "Have your father (who was general foreman) take that relief valve out and take it to the shop and test it." It blew off when he put the hydraulic pump on it at 280 pounds.

Chetwood Smith: I think that is the trouble with your check valve, you can build up any pressure on the service side; the relief valve is the most serious question. There is no relief valve now built which meets the requirements of the Boiler Code Committee of the American Society of Mechanical Engineers, because there is no relief valve built that is a true diaphragm in principle, designed to be attached directly to the pressure boiler. Generally they are on the principle of opening a small waterway for the relief. One of the most advertised valves today has an 8-inch relief, a Monel metal seat and rubber packing. The rubber packing will vulcanize under temperature onto the Monel metal and it takes four pounds actual strength to break that adhesion. You will have 256 pounds excess pressure before that valve will open, because the ratio of the valve is 64 to 1 against the pressure.

J. A. Jensen: One of the troubles mentioned is caused by placing the hot water coil in the fire instead of above it. Deposits are made in the pipe because in heating the water it is raised to boiling temperature. When water boils, lime and other deposits are made in the coil so that it finally becomes clogged, thereby interfering with the production of hot water and finally burns so that it must be replaced.

Hot water may be obtained by exposing a longer coil above the fire. With sufficient heating surface water will be properly heated without reaching the boiling point which causes deposits in the coil and back pressure in the tank. Under these conditions a generous supply of hot water is available without troubles from deposits or clogging. No check valve is needed and the meter is therefore safe against damage from this cause.

CLOGGING OF INTAKES BY FISH[1]

John N. Chester: I do not believe that those conditions under different circumstances would apply. From my own experience in Lake and River intakes, and with Lake intakes I may name Ashtabula, Ohio and Sheboygan and Marionette, Wisconsin, and Erie, Pennsylvania, we were not and never have been seriously troubled with fish. In investigating this question once on building an intake at Ashtabula, I, like Mr. Metcalf, submitted the question to an expert along the fish line, and the theory was rather that the Lake fish, or at least their spawn, and minnows, inhabited the shallower and warmer waters along the shore, and while we have had trouble, with the short intakes, with filling our pipes with minnows, if we go 1000 to 1200 feet out into the lake and put in a submerged intake, this is absolutely overcome. That intake is about the same as Erie and Marionette and Sheboygan, where they have no trouble with fish. Of course, along the Ohio and Allegheny Rivers the acid takes care of that question, because there are no fish.

Frank A. Marston: There were no eel troubles at this place. I have seen them elsewhere, but this particular intake is only troubled by smelts.

E. E. Davis: In our case there is no trouble at the intake, but small fish go through the screens at the entrance of the conduit supplying the pumps. The only trouble we have is in their going through the pumps, both centrifugal and plunger.

These fish are chopped up and they get in house connections and meters, thereby causing a bad as well as a fishy taste. As an old lady remarked to one of our inspectors, she was very fond of fresh fish, but did not like them in her drinking water.

A. U. Sanderson: The experiences that Mr. Metcalf described at Portland, Maine, could be overcome by the installation of travelling screens. At Toronto the stationary screens were blocked at intervals by debris of all kinds during storm periods and by frazil ice during severe winters.

[1] Discussion at Detroit Convention, May 24, 1923, on paper by Mr. Metcalf. See Journal, July, 1923, page 595.

The stationary screens were made in sections, 3 feet 3 inches by 4 feet 5 inches, and consisted of 4 mesh, No. 16, B. & S., copper wire, the water area being 63.5 per cent of the gross wire area. The velocity of water through these screens, at mean lake level, for the maximum demand of 65 million Imperial gallons, is 0.93 feet per second.

The travelling screens were installed in existing tanks, and are smaller for that reason than is desirable. The baskets have $\frac{3}{8}$-inch square openings of No. 12, B. & S., copper wire, the water area being 66.4 per cent of the gross wire area.

The velocity of water through the screes at mean lake level, for 65 million Imperial gallons, is 2.4 feet per second, and the velocity in the 72 inch conduit is 4.3 feet per second.

There are three kinds of ice that trouble water works men, anchor, floating, and frazil ice. The first will form on the bottom of streams and lakes, particularly on steel or iron, and will easily block small openings. Floating ice gives little trouble except in intakes of large capacity, laid in shallow water. Frazil ice is the most dangerous as it may occur anywhere between the bottom and the surface of the water and will block screens very quickly.

Travelling screens, motor driven and equipped with a hot water jet, will overcome difficulties with frazil ice.

Stephen H. Taylor: At New Bedford we have had quite a lot of trouble with fish in our screens. Our screens are at the outer end of our intake pipe, about 600 feet from the shore. We catch herring mostly and some smelts and eels. The tendency of a fish near the salt water is to follow the stream up and over fifteen miles from salt water we get the salt water fish. They travel against the flow of the water and that brings them naturally to the pond. Many times we have had to shut down our pumps on account of fish. We now have a revolving screen, and at times we have to run pretty slowly even with that. It is a common trouble, I think, for places within twenty miles of salt water. We have also had trouble with eels in pipes. They go through the eight mesh screen when they are very small, growing larger in the mains and finally get in to the tap, stopping it completely.

A. V. Ruggles: I wish to mention a roughly made intake crib which we installed on army work at St. Nazaire, France, for a 24 inch pump suction. Our crib consisted of a timber box with boards

covering about 50 per cent of the area of the sides and filled with broken stone. From this station we pumped through a line three miles long to a filtration plant, and one night I was notified that water had stopped coming through the line. I went over immediately and although it was dark I knew from the odor what the trouble was before I could see anything, as the 24-inch line had become completely blocked at the bends by eels.

At Cleveland we have had no trouble with fish. At the shore pumping stations we have ½-inch mesh screens and at the open equalizing reservoirs inland we have screens with openings ¼-inch one way and several inches the other way. When these basins are cleaned we find a good many fish and crabs, and in one instance we found a basin, emptied the first time in fifteen years, contained a carp which well filled a wheelbarrow.

FLUSH HYDRANTS IN CONGESTED CITY STREETS

Caleb Mills Saville: The question has been brought to my attention by the complaints of several of our local shop keepers in narrow and congested streets. They say post hydrants are a nuisance and annoy people. Some of the other city officials have heard of flush hydrants, hydrants under the curb, and that they have been successfully used. Boston used to have some. Providence has some now, Salem, Massachusetts, had some until they had a conflagration and then they abandoned them, I think. They are very unobtrusive because they are under the sidewalk and annoy no one except the firemen on cold, stormy days. As I say they have been used in several places, and it will be interesting and instructive to know what the members here think of flush hydrants. Insurance interests have little use for them, and as far as I am informed, water department officials generally are not at all favorable to their use.

Dow R. Gwinn: We had an experience with flush hydrants many years ago. We had nineteen flush hydrants or underground hydrants in a pit with an iron lid. We had a great deal of trouble due to water hammer in the closing of those hydrants. They seem to jump on the thread of what would be about 25 per cent of the opening, and the result would be a plug in the neighborhood blown out. That happened a number of times. Then the firemen complained about them. The result was that we took everyone out and put in post hydrants instead.

Stephen H. Taylor: In New Bedford we had a great many flush hydrants and they were a source of trouble until we got them all out. Whenever there is snow on the ground or when they are covered with mud, they are hard to find, and from our point of view they were very unsatisfactory. We now use post hydrants only.

John G. Valentino: If the gentleman would not mind giving a little detail, what does he mean by flush hydrants?

CALEB MILLS SAVILLE: The flush hydrant was known as the Lawry Hydrant at one time, I think. It is a supply pipe coming off from the main into a brick chamber and up to within a few inches of the surface of the ground, controlled by valves. The chamber having an iron cover over it. That hydrant may be, as in some of the hydrants in Boston, right over the main itself, so that you can get a tremendous volume of water from it, or a lateral may be run to the sidewalk and controlled by a valve in the street. The fire department comes on a fire call, takes off the cover and screws on what is known as a chuck or hydrant head weighing from 100 to 125 pounds and then it is ready for the attachment of the hose. Each of the outlets are governed by an independent valve. This flush hydrant of course has a very great advantage because of the large amount of water that can come from it.

THE USE OF 4-INCH LATERALS AND HYDRANT BARRELS IN COUNTRY DISTRICTS

Caleb Mills Saville: That also is a question which was thrashed out quite a bit by the committee who functioned with the committee of the National Board of Fire Underwriters. If you are familiar with the rate book of the National Board, you will note that 4-inch pipe and also hydrants 4 inches in size are penalized. The question I had in mind was how the members of this Association feel in regard to the installation of those smaller sized mains and hydrants in outlying districts where otherwise there might be no water at all. There is no question about the effect on fire fighting, but is it better to have no pipe or water supply, if the return for a number of years wlll not justify the larger sized pipes? And where the balance comes between a sparsely settled community where water supply is the first requisite and fire prevention perhaps a secondary one. There are many small communities and large ones too that have a great deal of 4-inch pipe in their systems, and if they did not have it it seems to me there would be obstruction to civilization and progress.

Stephen H. Taylor: I once had occasion to test a hydrant in a long line of 4-inch pipe at a factory which was insured by the Factory Mutual Insurance Company for which I was inspecting. This factory notified the company that a public water system carrying 150 pounds pressure had been extended to their property, and asked credit for it in their insurance rate. We made the test and found that, although the static pressure was 150 pounds, the flow through 50 feet of hose using $1\frac{1}{8}$-inch nozzle reduced the pressure to about 15 pounds. With a $1\frac{3}{4}$-inch nozzle on the hose the water just barely ran out of the nozzle. In other words, the hydrant was of practically no use for fire protection. The difference in cost between a 6-inch pipe and a 4-inch is so little as compared with the greater amount of water delivered, that it is well worth while to install nothing less than a 6-inch pipe.

STEAMER CONNECTIONS (4½-INCH) ON SUPPLIES HAVING HIGH PRESSURE, 75 POUNDS OR OVER. ARE THEY NECESSARY OR REASONABLE?

W. C. Hawley: That is a question which I should like to have answered. I am up against that proposition right now. I have taken the position that, with the ordinary fire hydrant, with 2½-inch hose connections, with pressures as in our case of 125 to 175 pounds, the 4½-inch connection is unnecessary, and worse than that, dangerous. If a steam fire engine or motor engine is attached to a hydrant under those pressures, I am afraid it might shake the hydrant off the lateral. One of the municipalities we serve demands that we set some hydrants with a steamer connection. I explained why I did not want to do so. They insisted and I said, "If you will assume the responsibility for any accident that may happen, including the financial responsibility for the damage if a hydrant blows off, we will set the hydrant with a 4½-inch connection." We had an order the other day to set the hydrants with 2½-inch connections and one is already in. In one division where we expect the pipes to be taken over before very long, we are setting some of these hydrants. There are a number in service. We have had no serious trouble with them, but frankly I am afraid of them.

President Cramer: I might state in my own case that, upon the introduction of motor apparatus, the question of large openings for pumper connection came up, the city paid for the first 20 hydrants with steamer opening and with this an agreement was made that the maximum pressure of 120 pounds be reduced to 90 pounds and that pumpers be used for all extra strong streams needed or for very large fires. We have found that it saves a considerable time in getting a pumper to work where the large suction is used rather than the two 2½-inch hose connections and is much more satisfactory to the Fire Department. After three years of use we have found no objection to their use. I should not consent to the use of the large suction in Mr. Hawley's case or for any pressure in excess of 100 pounds. The city in any case should pay for the added expense in furnishing the steamer hydrant.

W. C. Hawley: Since this matter came up, we have had an interesting test made. One of our politicians for some reason conceived the necessity of making a fire stream test. He was not sufficiently courteous to notify the Water Company that he was going to pull this test off, but he did notify the County Fire Marshal and some of the newspaper reporters and told the latter that there would be "something doing." He went into the thickly built up business district and on a block 800 feet long, six fire streams were thrown with one more taken at a distance of about 300 feet, making seven streams in all. The hose lines were 350 feet long, with the exception of one which was 500 feet. 1⅛-inch nozzles were used, except on two streams on which 1¼-inch nozzles were used. They did not take the pressure at any of the fire hydrants before or during the test, but did take the pressure at the nozzles of each of the seven streams. Under these conditions, the pressures at the nozzles varied from a minimum of 55 pounds at the nozzle at the end of 500 feet hose, to 80 pounds at one of the 1⅛-inch nozzles.

They then put the motor pumper on a fire hydrant diagonally across the street from the hydrant to which they had attached the 500 feet of hose and took water from one 2½-inch nozzle and delivered it through three lines of 2½-inch hose, each 100 feet long, to the turret on a chemical truck which was equipped with one 1¾-inch nozzle. With this additional draught on the system the pressures were again taken at the nozzles on the seven streams before referred to. On the stream taken through 500 feet of hose the pressure was reduced to 40 pounds. The pressures on two of the other streams were reduced from 60 to 52 pounds and from 68 to 58 pounds and the pressures on the other four remained the same as they had been before the pumper was started.

Because the pressures at the nozzles were from 40 to 80 pounds instead of 150 to 160 pounds, the static head, the newspaper reporters were told how inadequate the fire protection was and the public was informed by the papers that "millions of dollars worth of property and hundreds of lives were jeopardized by inadequate mains and pressures." Of course a reference to Freeman's tables and to the tables of the Underwriters demonstrated how wrong the conclusions were which had been reached and the newspapers promptly published a correction.

The interesting point about the test was that, while there was ordinarily a static pressure of 149 pounds on the hydrant to which

the pumper was attached, when the pumper was run for the first time, there was a pressure of about 40 pounds on the suction side with the pumper running. They then shut it down and closed the fire hydrant. Orders were then given to start the pumper again, but upon starting up no pressure was indicated on the suction side until one of the employees of the Water Company, who happened along, opened the fire hydrant properly and there was then a pressure of 100 pounds on the suction side with the pumper running and, as stated before, supplying three lines of 2½-inch hose through a 1¾-inch nozzle. The pressure on this nozzle while the water was being drawn was 74 pounds, which indicated a little less than 800 gallons per minute and with the other seven streams, there was a total amount of almost 3000 gallons per minute being drawn.

This test would seem to indicate, at least for pressures of 150 to 160 pounds, that a 4½-inch nozzle on a fire hydrant is not necessary and in fact that a pumper or fire engine is not necessary. If some accident happened and the pressure was materially reduced in the mains, the difference between a 2½-inch suction and a 4½-inch suction would be but a matter of a very few pounds. Undoubtedly, in the case of distribution systems where the pressure is comparatively low, fire hydrants should be set having the larger nozzles, but where the water pressure is high and the danger of accident to the hydrant is materially increased by the vibration of the pumper, there are serious objections to the use of the large nozzles, especially when we consider that the maximum effective suction lift which can be exerted is only a matter of about 10 pounds.

A short time after the so-called "test" was made, we had a real practical test at a fire which occurred in a large building in the same block. The fire had obtained a good start and was so threatening to adjoining property that the fire department of the city of Pittsburgh was called out and also the County Fire Marshal. Seven fire streams, the same number as used in the "test," not counting the pumper, were in service and the fire was put out within half an hour. Our company took occasion through advertisements in the local papers, to call attention of the public to the first test and its "results" as stated by the men who made it and the actual results obtained at a real test where a bad fire was extinguished.

Norman R. Wilson: With regard to the large sized opening for pumper connections, I have had a good deal of experience in testing

engines under all conditions, and I consider it is entirely unnecessary to have the large steamer connection in a hydrant, or rather to alter the hydrants that only have 2½-inch openings. The way to do that is to have a reducer on the large suction hose of the engine in order to attach it to one of the 2½-inch hydrant opening. You can then get as good a volume of water as you can with the large hydrant port. The short reduction to 2½-inch opening does not decrease the flow, it simply increases the speed at which your water comes through.

You cannot, however, get the same results by connecting the engine suction to the hydrant by means of two 50-foot lengths of hose to the two sides of the hydrant as the friction due to the long lengths of hose considerably reduces the flow and further the ordinary hose is not a suction hose and is liable to collapse should the pump suction pressure be in excess of the discharge pressure at the hydrant.

I would certainly not advise anyone to go to the expense of altering existing hydrants to those having steamer openings. It is simply a waste of money. Of course, if new hydrants have to be put in, the special large steamer opening should be provided as it saves attaching the reducer to the engine suction.

James E. Gibson: My experience does not cover 75 pounds pressure on distribution mains as we only carry about 40 pounds. Our chief of fire department specifies steamer nozzles for all hydrants. We put them in, however, in the business sections only or where we consider that in future they may be needed.

Our fire department pumpers carry the full size hose for the steamer nozzle, but, as the last gentleman stated, this hose is fitted with a reducer to fit standard 2½-inch nozzles, and, without exception, the firemen always connect to the 2½-inch nozzle without regard to whether the hydrant has a steamer connection or not. With 40 pounds pressure on the mains I have yet to see them pull a vacuum on the suction of the pumper.

G. E. Shoemaker: At Waterloo, our fire department is equipped with motor pumpers. Nearly all of our hydrants in the downtown districts and in the large fire districts have steamer connections, but I do not believe that in the nineteen years I have been in Waterloo, there has ever been a hose attached to these steamer connections. The fire department uses the two 2½-inch connections.

I think, however, that the Board of Fire Underwriters might possibly make some objection if we did not have the $4\frac{1}{2}$-inch connection, and I think one of their recommendations was that the fire department be equipped to use the steamer connection if necessary.

J. W. McEvoy: At Dubuque, Iowa, we carry a pressure that varies from 85 to 125 pounds. We have $4\frac{1}{2}$-inch steamer connections on practically all our hydrants, and the fire department uses the $4\frac{1}{2}$-inch in every case and never have any trouble, even with the 155 pound pressure hydrants, from a hydrant blowing out or getting out of order.

A. S. Holway: We place nothing but hydrants with steamer connection, and our fire department uses them invariably. We feel it is worth the small extra expense. We have had no trouble, although we carry pressure as high as 125 pounds.

George F. Merrill: Replying to Mr. Hawley's statement as to the liability of hydrants blowing off the connecting pipe where under high pressure, and the inference that the standard $4\frac{1}{2}$-inch steamer connection causes somewhat greater flow of water than the standard $2\frac{1}{2}$-inch hose nozzle, thus tending to more severe water hammer on closing of hydrants, I believe that it is good practice to strap hydrants on or brace them securely, whether steamer connections are used or not, in cases where water pressures run high enough to create any liability of their blowing off. This is very essential as insurance against water damages to private property arising from any breaks of this nature; and also well worth the slight expense required in preserving the continuity of fire and domestic service.

As to the use of steamer connections, the added expense is small, only about \$3 or \$4 per hydrant if hydrants are ordered so fitted. The steamer connections are recommended by the underwriters, and undoubtedly add to the efficiency of the fire department through the use of standardized connections. They furnish water also with the minimum amount of friction loss through the hydrant.

John N. Chester: Mr. Holway's statement puts me in mind of a question that I believe some one down in Tennessee wrote to a mail order house in Chicago, describing a piece of timber he had, and wanted to know the price of a sawmill to cut it up, and they wrote back to

him that a sawmill for that purpose would cost $2500, and he replied "If I had $2500 what in hell do you think I'd want with a sawmill?" And if Mr. Holway has 125 pounds pressure, I would like to know what he needs with a steamer connection?

A. S. Holway: That was on our old high pressure system, which has been amalgamated with the regular system. We now carry 80 pounds. That was put on at the recommendation of the fire underwriters. Our whole city is now on the fire engine stream basis, and we carry only 80 pounds.

John N. Chester: The hydrant connection then only becomes a matter of convenience to attach the size suction hose they have to your hydrant?

A. S. Holway: No, it comes down to a question of fire rates in the end. We have certain deficiency points to overcome and the underwriters put quite a heavy charge against small hydrants and it is just a question of dollars and cents. It pays. We have not replaced all the old hydrants with the 2½-inch openings, but there is a great deal of friction on a 2½-inch opening at a thousand gallons a minute; the friction at that point is too high to be carried, it does not pay.

John N. Chester: It will fill the pump.

A. S. Holway: Yes, but it carries the pressure too low, makes too much work for the pump.

J. G. Valentino: Did I understand Mr. Gibson and one or two of the other gentlemen to state that two 2½-inch connections were just as satisfactory or you would get as much water from them as you would from a 4½-inch?

Dow R. Gwinn: I do not see any difference. As a matter of fact, if there is sufficient pressure, they will get all they can take care of with their pumper with two 2½-inch openings.

William W. Brush: Our standard low service hydrant has one 2½-inch and one 4½-inch outlet. The water pressure at the hydrant varies from a minimum of about 25 pounds to a maximum of over

100 pounds, the average pressure being approximately 40 to 45 pounds. No difficulty has been experienced by the New York Fire Department in using the larger size outlet. If the fire department of any community is equipped with fittings that increase from 2½-inch to 4½-inch and such fitting be placed on the 2½-inch outlet to the hydrant with a 4½-inch hose running to the fire engine, the reduction in delivery from the hydrant with the 2½-inch outlet as compared with a 4½-inch outlet would be very slight, and practically negligible. We believe that the convenience to the firemen in connecting up their large suction hose to our 4½-inch hydrant outlet is of sufficient value to justify the use of this larger outlet, but if any community is equipped with 2½-inch outlets and wishes to deliver a larger quantity of water to the fire engine than will be furnished with a 2½-inch hose, such community can get practically the same delivery of water to the fire engine by using 4½-inch hose with a reducing coupling between the hose and the 2½-inch outlet as would be secured if a 4½-inch outlet to the hydrant were provided.

A MEMBER: Is it good from a waterworks standpoint to go to that extreme? Is it not the job of the pumper to take the water at a fair service pressure and deliver it at the fire pressure?

PRESIDENT CRAMER: As to expense, we who are under contract to furnish an agreed pressure have no choice in the matter, we are all hoping to get away from the responsibility of furnishing fire pressure and we hope the campaign started by Mr. Charles Henderson and so well championed by Mr. Jensen at the Canadian Section this week will bear fruit and that the day will soon come when we will furnish volume under normal pressure only.

ISAAC S. WALKER: I have been much interested in this discussion because, as it happens, the three different water companies with which I am associated, one in Pennsylvania and two in Indiana, have all been inspected and reported upon by the Fire Underwriters during the past year. The two Indiana reports, being for cities with a population of less than 25,000, were made by the Indiana State Inspection Bureau. The report on our Pennsylvania plant, being for a city greater than 25,000 population, was made by the National Board of Fire Underwriters. The National Board only deals with cities in excess of 25,000 population.

Whether made by the National or State Boards, however, all the reports on these cities were in the same general form. The recommendations covering hydrants were: "That all hydrants installed in the future have one $4\frac{1}{2}$-inch steamer connection and two $2\frac{1}{2}$-inch outlets; not less than 6-inch barrel, $5\frac{1}{4}$-inch valve opening, and 6-inch connection to main provided with a gate valve."

These are evidently general requirements by the Fire Underwriters for all cases, and it would appear that they did not give consideration to the pressure on the system in their specification for the size and outlets of hydrants. As to the particular point under discussion, there is no question that the usual $2\frac{1}{2}$-inch outlets will, at 75 pounds pressure, deliver all the water that would ever be required by a pumper. From one hydrant, in fact, if this pressure were maintained, one $2\frac{1}{2}$-inch outlet would be adequate when coupled to the fire pump suction.

The question stipulates 75 pounds as the pressure above which it may be unnecessary to provide steamer outlets. By inference, we might assume that it would be desirable to install steamer connections where pressures fall below 75 pounds. Now it is within the bounds of possibility that, even in the best operated plants, working under average pressure of 75 pounds or greater, that pressures in a district where a fire occurs may fall below 75 pounds and in case of excessive demand, or break or accident during the fire, the available pressure at the hydrant may be reduced to only a few pounds.

Under such conditions, the $4\frac{1}{2}$-inch outlet to the pump section would be practically indispensable, and this, I judge, is the reason for the more or less universal condemnation by the Fire Underwriters of installing hydrants without steamer outlets. It is simply a question of having a suitable size suction for the fire pump available under any low pressure conditions in the piping system.

City governors, furthermore, being interested in low insurance rates for their community, while they may be lax in following the Underwriter's recommendations, as applied to themselves, are usually pretty keen in requesting the water company to comply. It would seem to the speaker, therefore, that the wiser policy in this matter is to use hydrants with steamer outlets, in accordance with the Underwriter's recommendations. The additional cost is not excessive; it will satisfy the public, and, in the case of low pressure emergency, they are there for service.

W. C. Hawley: The question of insurance does not enter into this problem at all. The thing I have been afraid of is the blowing off of hydrants due to shock and jar of the engine. Our plant has been inspected by the County Board of Underwriters and passed as one of the best in the county. The Board has not requested the $4\frac{1}{2}$-inch nozzle, and the engineer of the Board has told me they do not want it.

Dow R. Gwinn: The point Mr. Hawley makes is that it is not a matter of insurance, but a practical question, that the pulsation of the pumper may blow off the hydrant. After I had some correspondence with Mr. Hawley, we had occasion to put in about 15 five-inch hydrants along a street where the sidewalk would probably be excavated, leaving the hydrants in the areaway, so I took the precaution of having a shackle put around between the main and the fire hydrant, about $1\frac{1}{4}$-inch round iron, so as to be on the safe side. We have not had much experience with pumpers yet. Some of the rest of you may be very sorry that they ever had pumpers put in, if they have large connections.

William Luscombe: After all it seems to me it resolves itself down to purely a question of local conditions, such as the pressures required to furnish satisfactory service, requirements of the Underwriters, also other factors that effect the case.

Stephen H. Taylor: In New Bedford we carry pressures up to 90 pounds and have $2\frac{1}{2}$ and $4\frac{1}{2}$-inch nozzles on all our hydrants. The pumpers almost always want the $4\frac{1}{2}$ and we have had no trouble from blowing out of hydrants. We back them up in trenches with heavy blocks and stones.

WHO PAYS COST OF METER REPAIRS WHEN DAMAGED BY HOT WATER?

John N. Chester: I think a good clause in the water rules is that the consumer shall pay for all damage from external causes or extremes of temperature.

A Member: On that clause there is one point I believe that is a little bit broad; if the meter is installed in a pit designed by the water company or municipality and the meter is set there on your order, why hang it onto the other fellow?

John N. Chester: There is always an accompanying rule that the consumer shall furnish the housing for the meter.

William Luscombe: At Gary, Indiana, any repairs to the meter on account of damage by hot water or frost is charged to the consumer. Such meter repair bills are attached to the regular water bill. As has been stated, sometimes the consumer postpones paying for the meter repairs, but we make collections in all such cases without exception; in fact, in an extreme case of nonpayment we discontinue the service the same as for a delinquent water bill. However, we have been obliged to resort to that method in only a very few instances.

In order to prevent damage to the meter by hot water, we have used various socalled relief valves in connection with the ordinary check valve, but we have never found a satisfactory relief valve, that is, one that was absolutely dependable and positive in its action, and which we could recommend or be responsible for. The nearest thing I have seen approaching such a positive device in my estimation is what is called the "red top" relief valve, recently manufactured by a Philadelphia concern. It is claimed to be noncorrosive and rust proof and the only working part is a solid lead ball, the application of which is upon the dead weight principle. I should be interested to learn if anyone present has used that valve, and, if so, with what success.

We experience a great deal of trouble on account of damage to meters by hot water, and I should like to hear from anyone who has used check and relief valves or other means to overcome it successfully.

J. W. Toyne: We do not place a check valve to prevent hot water going in the meter, due to the hazard from the possibility of explosion. I will say though that we invariably collect for the damage done to the meter through hot water and through frost, when the meter is installed in the housing furnished by the consumer. However, if the meter is set in one of the pits that we put in to house it, we have not the nerve to collect on that.

Frank A. Marston: There is a valve known as the Stack valve which is made in the vicinity of Boston and perhaps is more of a local article. It is really a faucet which takes the place of the hot water faucet in the sink nearby, and as such is used frequently the same as any faucet in the house, and for that reason stands a much better chance of being in working condition when needed than valves put on top of the hot water tank which are not used except perhaps once a year, or more infrequently when the pressure goes up. As a property owner, I object seriously to putting a check valve on the service line. I prefer to take the chances of paying for damage to the meter in case the hot water goes back rather than to depend on an automatic valve.

John N. Chester: I have been connected with the operation of over fifty water works and have not heard this question of hot water destroying meters raised often enough to make it a hundredth part of one per cent. I think we are treading all around a small thing and taking a whole lot of time to do it.

GENERAL DISCUSSION ON SETTING METERS

Dow R. Gwinn: When the last big lot of meters were set in Terre Haute in 1915, a lot of repair business was done by the plumbers. We gave the consumers about a month's notice. One of the plumbers came in, a plumber who had been in business for a great many years, and he said that he had a customer in whose house he had done plumbing for eighteen years and during that time the consumer had a water closet that ran for eighteen years; he was positive because he had asked the man every time he went there, "Shall I fix up that water closet for you?" "Oh, no, that does not bother me any, let the water company pay for it; I have not got a meter." But the plumber said that the day we put the meter on this man called him three times, "Come down and fix that water closet, the water company has put a meter on." I do not know but that thirty days is sufficient notice.

John N. Chester: Do you not think you had better charge him the first month, and if there is any negotiation at all, let it be an adjustment of the bill? Let the charge start the day you get the meter on.

James E. Gibson: I think if you begin to compromise on the first bill, you will be continually troubled with compromises. Whatever a customer's excuse may be, it is a good one to him, though it may be a poor one to you.

G. E. Shoemaker: At Waterloo, Iowa, we started setting meters on all consumers in 1910. We wrote a letter to each consumer notifying them that on a certain day we would be there to set a meter, and, beginning from the date the meter would be set, water would be charged on a metered basis. We advised them to secure a plumber to repair leaks, so that all wastage of water would be stopped prior to setting the meter. We had no trouble of any kind by this method.

James E. Gibson: I want to add one point to what I have said, that is, when we put meters in in Charleston we had about 5500 consumers and were pumping around 7,000,000 gallons of water per day. Today with over 9000 consumers we are pumping approximately 5,500,000 gallons, an increase of 63 per cent in consumers with a reduction of over 20 per cent in the amount of water pumped.

John N. Chester: I think they say 44 out of 48 states have utility commissions and with them we file our operating rules, and if they keep those rules filed they are law, and if we do not outline whom we have a right to meter we have fallen short in our filing; if we do, we have got that matter settled.

Stephen H. Taylor: In New Bedford our city solicitor ruled that while we could insist upon payment by meter measurement we could not force a consumer to buy the meter. We give him the option of either renting or buying.

J. M. Diven: We put the meters on as our leak detectors. Is it not fair to let the consumer have the benefit of the leak detector to point out the leaks to him, giving him opportunity to stop them before he is charged for the water they waste? Small leaks are not easily found and a plumber or other person going over a house might easily fail to detect a leaking water closet or other fixture. But the meter would tell that there was a leak and cause a more thorough examination. A water closet might be leaking several hundred gallons a day without the owner noticing it. When he gets notice that a meter is to be set he thinks that all is right with his plumbing and so he does nothing about having leaks stopped. Of course, you will say the water is wasted just the same and should be paid for, but is not the saving in friction and the satisfaction of the consumer worth more than the water wasted? When the meter has told a consumer that he is using an excess amount of water or is allowing it to run to waste he is not entitled to any sympathy or consideration if he does not try to correct the fault.

LEGAL DECISIONS ON RIGHT TO CHARGE MORE THAN ONE MINIMUM RATE OR SERVICE CHARGE ON MULTI-FAMILY HOUSES

John N. Chester: I wish to commend to you in answer to your question the definition of the term "consumer" formulated by the New Jersey Commission and which has been adopted, I believe, as a standard by a great many other commissions.

It is as follows:

"Consumer" as used herein shall be the party receiving service for a property as hereinafter classified, i.e.,

a. A building under one roof owned by one party and occupied as one business or residence, or

b. A combination of buildings owned by one party in one common enclosure occupied by one family or business, or

c. The one side of a double house, having a solid vertical partition wall, or

d. One side or a part of a house occupied by one family, even though the closet and other fixtures be used in common.

We found in our practice, in order to meet all conditions arising, the necessity of adding to the above two stipulations as follows:

e. A building owned by one party of more than one apartment and using in common one hall and one entrance, or

f. A building owned by one party having a number of apartments or offices and using in common one hall and one or more means of entrance.

And as explanatory to the above we generally append the following:

Each consumer will be supplied through a separate meter, where service is by meter, except, however, in the case of (*d*), (*e*) and (*f*) as above defined, should the landlord or owner desire that the accounts of each consumer be kept separate he must first provide means of supplying, controlling the supply, and housing the metering device for each tenant, the controlling device to be outside the building and the measuring device or meter to be properly and conveniently housed either outside or within the building.

The Pennsylvania Commission has commended to utilities the above definition and you will note that, if you adopt the same, you will have the right to charge more than one minimum on a multi-family house.

As regards which option the landlord will elect it matters little, for, if he assumes the burden, he buys water by meter, pays one service charge or minimum and a much larger consumers' charge than otherwise, from the fact that the consumer pays by flat rate, or, if he makes it possible for you to deal with each family direct, you receive two minima or service charges and a smaller consumption charge and in the end the results are practically the same.

W. C. Hawley: In the case of the Vandergrift Water Company, Westmoreland County, Pennsylvania, the courts decided that a minimum rate might be charged for each occupancy or tenant. I believe the particular case was that of a building in which there were stores on the first floor and apartments above. That brings up a very nice question of management. Our rule provides that where a property can be divided and sold, we charge a minimum rate; we do not attempt to charge for separate apartments; we do not attempt to charge a multiple minimum for duplex houses because of the practical difficulties. For instance, we have one apartment house with some fifty odd apartments; now, if we did charge a minimum rate for each one of those apartments, every time a tenant moved out and the apartment is vacant a few weeks, there would be an adjustment of the minimum rate. We find as a practical matter that each apartment used on the average more than the amount allowed by the minimum rate, and we charge therefore one minimum and collect at stated periods for the water used.

Dow R. Gwinn: That is the plan we work on.

John N. Chester: We had a case, during the war, at Edgeworth, Pennsylvania. We had a house shortage and our consumption was increasing and our revenue was decreasing disproportionately to our operating expenses, and we cast about for how to get more revenue. It occurred to us that probably one third of all the houses in that district had rented out rooms during the war, on account of the house shortage, and fully another third had taken in a second family, and we wrote the Public Service Commission asking them for permission to inflict double minima where there were two families occupying a house and compel the families to divide the consumption charge, and, if they refused to do it, to shut the water off from the whole building and not turn it on until both bills were paid,

holding the landlord for it. In the emergency, they allowed us to do that, but that was a war emergency and we still hold the rule and charge them two minima and the consumption charge is divided between the families.

A. S. Holway: We are on a service charge basis; we charge one service charge on each meter, we do not care whether there is one person consuming from that meter or a thousand; I think that is the fairest way.

Isaac S. Walker: We have one case which is a little aside from the question, but may be of interest. In one of our towns there is a large industrial concern, which has a community village of about 125 houses, for the use of their employees. Being a private enterprise on their own property, they installed their own street mains for water supply.

It is the practice of this concern to furnish their employees with free water, and when they applied for water service, several years ago, the question arose as to how to charge for this strictly domestic service, under a set of rules which prescribe that each house be considered as an independent service. The owners of the concern would not install separate meters in each house, as they furnished water free, and were not interested in the amount used in each house. We would not install the meters as it was a private enterprise. The question was settled in what seemed to be the most satisfactory way by locating a single large meter on their supply main and taking the total registration as the basis of billing. The bill could not be computed in the regular way, as the combined consumption would run into the lower sliding rates of the schedule, thus giving the owners the benefit of industrial rates for small dwellings. So the total registration is decided by the total number of houses connected, to ascertain the average amount used in each house, and the unit bill is computed on the basis of this consumption. If this average amount is below the minimum allowance of 3333 gallons, each unit bill is considered to be a minimum bill, and the total bill for the 125 houses is rendered on this basis, i.e., 125 times the unit minimum bill. This method reduces the billing to the equivalent of individual metered service, and was accepted without question by the property owners.

W. S. PATTON: Take a business house; they put in one meter and probably one store will occupy the whole building. Later on, maybe the building will be divided up and there will be three or four stores on the first floor and two or three factories on the other floors. The original meter worked all right in the beginning, but now each of those tenants wants a separate meter. What is the general custom with other superintendents? As many meters as they want in the basement, or to supply the water to the landlord and require him to be responsible for all the bills and let him supply his own meters and bill his own consumers? It is a problem with us. It seems to us that the water works ought to endeavor to supply the need as far as it can; in other words, give the consumer whatever he wants, but charge enough to make it pay. I should like to know what other people are doing.

JOHN N. CHESTER: Give the owner of the building his choice; let him divide up his plumbing so that you can deal with each consumer or let him pay the whole bill.

W. S. PATTON: Would the water works supply all those meters at its own expense?

JOHN N. CHESTER: If they built a row of houses, would you not be glad to supply meters for them?

W. S. PATTON: Here is the proposition, you open a lot of new accounts and in a little while some of those meters will be taken out. It means taking meters out and putting them in. I do not see any disadvantage in that, the only thing is the extra expense.

JOHN N. CHESTER: Do you not have a place for those meters when you take them out?

W. S. PATTON: We placed all our meters at the curb. We have one line going into the building; this other way, the landlord would have to put service lines down to the basement and the other meters would be placed in the basement. I want to find out whether that is the custom with the other plants. We make no charge whatever for installing the meters.

James E. Gibson: Charleston is peculiar in this regard because in anti-bellum times the slaves lived in tenements in the rear of the main house. In more recent years those tenements have been remodeled and rented out as tenant houses. When we took over the water company we adopted a rule that we would grant only one service to each premise unless conditions required more than one service to supply adequately the property. The question at once arose as to what constituted a premise, and, after considerable thought, a premise was defined by our board as a property that can be entered from the street without invading the privacy of any other person, or in the case of apartments or twin houses an entrance wherein a person might take refuge from storm without invading the privacy of any of the tenants of the property in question. Under this definition we will grant services to each of the apartments. In addition to this we have to take care of the tenant houses in the rear, mentioned above, in which case we add an additional minimum to the service charge for the rear house. This service charge is based upon the size of the apartments in the rear, that is, the number of rooms. If the owner desires it, and will grant the permission, we will lay additional services for each of these tenant houses, in which case we charge the full minimum the same as if the property faced the street. It goes without saying that these additional services are furnished with meters. It would seem, therefore, that we had eliminated trouble, but far from it.

A party will build a twin apartment and comply with our requirements as to separate entrances and privacy of entrance, but then comes the plumber and he is only out for the money; not caring anything about how the water is supplied so long as he makes connections and gets the water to the premise. The result is that Mr. A, who lives in the second story apartment, desires a water closet for his servant and makes a contract with his plumber to install this closet. Those of you who are not familiar with conditions in the South must understand that these closets are always installed in small buildings in the yard as the people will not permit the servants, (negroes, as a rule), to use the fixtures of the main house. The plumber, without rhyme or reason, connects the water supply of this toilet, in a good many instances, to Mr. B's supply which is the downstairs apartment. Things go along nicely until this closet (usually of the cheap variety) breaks loose and runs up a high water bill. Mr. A knows nothing of this as he never inspects

the servant's toilet, but when Mr. B receives the high water bill he "goes up in the air" and after investigation finds that the cause of this high water bill is Mr. A's servant's toilet, but the water department insists upon Mr. B paying the bill, and, of course, we get the blame. In most of the instances we have been able to act as peace-maker between Mr. A and Mr. B, and get the matter finally adjusted without getting our fingers burnt, but it is not always so rosy.

However, we refuse to set more than one meter to a premise and do not permit submetering. Occasionally, the owner is desirous of metering each tenant in his houses so he will undertake this submetering himself in which case we sell him the meters at actual cost to us plus a small fee for storage and interest. However, we have nothing to do with the reading and billing on these meters. I can recall two or three cases, but usually after a few months they come back and ask us if we will not take the meters off their hands as they find it too much trouble and would rather pay the full minimum themselves, and charge the tenants a sufficient sum to cover the water in the rent for the apartments.

We had one other difficulty to contend with and that was that of the split service; that is, one tap would be made on the main and a service pipe run to the sidewalk and then split into several services. We have had to abandon this as we found it unsatisfactory.

Dow R. Gwinn: Mr. Gibson is right; I do not know anything in the water works business that is rosy unless it is drawing your pay.

W. C. Hawley: I think this question of more than one meter in a property usually solves itself, at least in the north, by the fact that the plumber, when he installs the plumbing, does not install it for each separate apartment or each separate store. He has one hot water system for the whole building and you cannot put a meter in that will meter the separate apartments. When the landlord comes in and wants to do that, all you have to do is to say, "Fix your plumbing so it can be done." He goes back and interviews the plumber and decides that he will go along just as it is.

J. W. McEvoy: It seems to me there are two ways to look at this; one, the municipal plant, bought, paid for and owned by the people who are entitled to the very lowest possible rates and the best

accommodations; the other, the privately owned plant, paid for by a privately owned company or corporation who have no way of getting any revenue other than from the consumption. In that case there is not any question but that they must cut every corner and increase their revenue as much as possible to make an earning, to make a profit and take care of depreciation. Now, in a municipally owned plant, it seems to me it is only fair to the property owner who has paid for that plant in a tax, to have the privilege, if he so chooses, to put in one meter to serve as many tenants as he sees fits. In Dubuque we allow the owner to serve as many tenants as he sees fit through one meter.

EXPERIENCE WITH FLUSHOMETER WATER CLOSETS

Dow R. Gwinn: This is a live question, as very large services are being demanded for such closets and the large flows required may involve water hammer trouble. Water works authorities should regulate their use before they are in too general use. I shall say in the beginning of this question that we had a plumber come into the office about a year ago and he said, "I put in a flushometer closet and I want a 1¼-inch line." "How large a house is it?" "Five room house; he has one of those flushometer closets." I said, "We cannot supply a 1¼-inch line; if we supplied him with a 1¼-inch line, everybody else might want one. We will run a ⅝-inch line to the curb, and 1¼-inch can be laid from that point." A 40-gallon range boiler was installed in the basement and the 1¼-inch line connected at the bottom, the supply for the water closet was taken out near the bottom with a pet cock at the top and at the bottom. It gathered considerable air and furnished a cushion, and the air pressure gave a very satisfactory flush. Every now and then it would be necessary to drain this tank and fill it with air again. It is a good deal better for us than putting a 1¼-inch line from the main where a ⅝-inch will answer.

John N. Chester: I did not intend to say anything on this question this morning, but since I expressed views contrary to what you quoted for me, I must at least harmonize them. First, I like your plan, if you are intent on keeping down the size of your service, but Mr. Gwinn quotes me, I think, from a discussion wherein it was a question whether they should have the whole system piped into a place, or a reasonable proportion of it. I do not regard a 1¼-inch pipe, with a meter between the user and the main as detrimental, except on single lines of 4-inch pipe, for I believe that we might gain considerable revenue by permitting the 1¼-inch connection or service if we have a heavy service charge graduated according to size of service and meter, that is, it steps up with every increased size, and if you have a $6.00 service charge for a ⅝- or ½-inch pipe, it ought to be at least $1.00 more for 1-inch and $1.50 more for a 1¼-inch pipe per month. That type of minimum has solved the question for us. There are

very few people who want flushometer closets when they find that they must pay an additional service charge or minimum in order to get them and if your service charge does not provide for it, if you have not a graduated charge, let me urge that that graduation is the easiest way of regulating the flushometer closet. When you get into a community such as one of our clients who is supplying the village of Edgeworth, where the houses are all large and the population is constituted of that class of people who want what they want when they want it, regardless of cost, if they are willing to pay for it, let them have it. We do not discourage a man at all if he comes in and applies for a 2-inch pipe. We only wish to be reasonably certain that he is going to continue to use that 2-inch pipe if it is put in; so he gets a 2-inch pipe if he wants it, or if he wants a $1\frac{1}{4}$-inch pipe he gets it, but he is given to understand that his minimum will be so much and he is going to be held a certain number of years for that minimum if he is the property owner; if he is not, he cannot get the service. That policy has increased the revenue and has not impaired the service.

W. S. Cramer: What size meter do you use?

John N. Chester: Generally we put a $1\frac{1}{4}$-inch on a $1\frac{1}{4}$-inch line.

W. S. Cramer: We found in many cases that the trouble was overcome by running a $1\frac{1}{4}$-inch pipe and in almost all cases it was on the short side of the street. The $1.50 minimum a month did not stop the use of flushometers, but a three dollar minimum did.

W. C. Hawley: This flushometer proposition came up with us some years ago, and I immediately took the position that while we were willing to furnish all the water that the consumer wanted and we were glad if he took a lot of it, we were not willing to furnish 99 per cent of the water in 1 per cent of the time. By the use of a tank such as Mr. Gwinn has suggested, or a piece of 8-inch pipe, 6 feet long, or an air tank, we have solved the problem. We are furnishing in one case, a schoolhouse with 20 flushometer closets and a one inch service line, with an air tank, and they get satisfactory service.

Chester R. McFarland: One or two questions arise in this matter that are interesting. The first question is, what is the effect

on the meter of the use of flushometer closets? Does it not destroy the meter in a short time, the opening and closing of those flushometers? That is one of the questions with which I am not familiar, and I am asking for information. Now there is another side of this that probably has not been thought of; you take a number of those large services, $1\frac{1}{4}$-inch and $1\frac{1}{2}$-inch to supply these flushometers and let a fire break out in that district and, the first, thing you know, fifteen or twenty houses having these large openings in them burn down and what is the result? If that district is made up with 6-inch mains, what is the result of the pressure you can maintain on your system with all these flushometer pipes open and running when the fire is going on? It seems to me that that is a very serious side of this question. That is the reason I am limiting, as I always have done, the size of connections for sprinkler systems. Now if we are going to step off in another direction and do the same thing, it seems to me we are likely to have bad results in case of any large fire. These are questions that have arisen in my own mind. Some of you gentlemen might be able to enlighten me as to the effects under those conditions.

John N. Chester: In our case, if a conflagration like that is going on in the residence district and our superintendent did not have a man down there with a wrench to shut off those houses, there would be a new superintendent in that plant next day.

Chester R. McFarland: That all sounds good, but practice is another thing.

John N. Chester: The next thing is the demand made by several against the demand of one; there is only one-sixth the chance of that curb cock being covered up by the building falling down as against the one chance in the factory, assuming there are six houses burning. Of course, the large connection in the factory would not be so detrimental, if it were not for the breaking off and the impossibility of getting at the shut-off when the break occurs, but you have reduced that to a minimum by the number of services in question.

I may be educated up to this by this very district where the wealthy people of Pittsburgh have built homes with bath rooms numbering from three to ten in a house; leave out the flushometer, say they are equipped with a common closet, and what kind of service are you

going to give them with five, eight or ten bath rooms? That system has a lot of 4-inch pipe in it and that company is going to have water enough to keep its mains going as long as the revenue from the investment is commensurate with the investment. We have not felt any inconvenience from those large services in the Edgeworth District, which however is not a large district. It has only a 12-inch main coming from the reservoir and there are other districts beyond that to take water through the same 12-inch main, a large percentage of the pipe laid in that district is 4-inch; it was laid before I had anything to do with the plant. There has been nothing but 6-inch laid since, but we are not suffering the way you people think you are going to suffer. They do not all draw at once; if they all took a notion to flush their closets at once, there would be a diminution of pressure and they would wait, but that does not happen, those complaints have not come in and we are getting the greater revenue from the larger services.

A. S. Holway: We have had the same experience Mr. Chester has had. That was one of the principal reasons we changed from a minimum charge system to a service charge system. We believe the customer is entitled to whatever he wants and is willing to pay for, and we have no difficulty whatever from flushometer service.

C. W. Schiedel: How large a service is required if there is one flushometer in the house?

Dow R. Gwinn: Five-eighths inch. I want to give a consumer as large a pipe as necessary, but if a $\frac{5}{8}$-inch service will take care of the service including flushometer, why should I go to the expense of putting a $1\frac{1}{4}$-inch pipe from the main up to the curb at our expense? Why should we have the extra large pipes if $\frac{5}{8}$-inch will answer the purpose, and we have demonstrated that it does work all right? In several large buildings recently they wanted to put in flushometer closets, and we discouraged them as much as we could. I am speaking of a large business house, five or six stories high, where they were putting in a 2-inch line, but they put a tank on the roof with a return pipe coming down to the flushometer closets. When a prospective consumer comes in and talks about the flushometer closet, I tell him the experience I had at the Bellevue Stratford where the closet was not supplied with sufficient water to get a satisfactory flush. I went

to the Claypool at Indianapolis and they had put in such a good one that the water was thrown out on the floor. This is something of a fad that is going to run out after a while. In the meantime, if they want to have that kind of fixture they can put a range boiler in the basement.

William W. Brush: With your tank or boiler in the cellar, as I understood, you had to replenish the air about every three or four months.

Dow R. Gwinn: I do not think it is oftener than that.

William W. Brush: Have you ever tested how much air is left in the tank?

Dow R. Gwinn: No.

William W. Brush: Did you ever try to by-pass your tank?

Dow R. Gwinn: No. As long as the man and his wife were satisfied, we did not bother.

Henry P. Bohmann: What is the minimum pressure?

Dow R. Gwinn: We have about 45 pounds in the residence district.

J. M. Diven: In allowing large direct services for flushometer closets, are we not doing very much the same thing we would be doing in supplying locomotive cranes direct, without the use of a tank? I do not think many of us would sanction a direct connection for a locomotive crane, as they use very large outlets, 8- or 10-inch, in order to be able to fill the locomotive tank quickly. A direct connection for this purpose would be apt to cause very serious water hammer, and would not the same be likely to occur if we allowed the services as large as are requested for flushometer closets. A hotel or apartment house would need about as large a supply pipe for this use as the railroad would for their crane if directly connected, and there is no telling how many closets might be used at the same time, all shut off suddenly, causing considerable water hammer.

J. W. Toyne: With the flush valve installation we have, we have found in almost every case that a $\frac{3}{4}$-inch service is large enough from the street to the property line, with $1\frac{1}{4}$-inch piping inside.

J. Walter Ackerman: Relative to the question of the expansion tank, in connection with the use of the flushometer, some years ago I put in an ordinary 40-gallon heating tank, as an expansion tank, in order to provide a cushion for the registration of a recording gauge to dampen out the water hammer due to some water elevators near by. It was fitted up so that, with a glass gauge near the top, one could tell where your air line was. It was fixed so you could by-pass around it and empty it when it was absorbed. Now my experience was that a 40-gallon tank would absorb all the air I could get in there, inside of twenty-four hours. I thought when I was building the thing that that would be a very fine arrangement but I did put the glass in so I would know exactly where my water line came. Inside of twenty-four hours I had no air left in the tank.

J. W. Toyne: I have a tank that carries just the atmosphere air for over two months.

LOCATION RECORDS OF WATER SERVICES

JAMES E. GIBSON: We inherited a complicated condition. The private water company had no definite or systematic policy. When the Goose Creek supply was first introduced they had a surplus of water and a deficit of consumers. In order to obtain consumers they would lay service pipes under almost any condition, across lots, into the rear of houses, and if they did not happen to have a main on the street on which the prospective consumer lived, they would go to the next street or even as far as two streets away and lay a small service pipe to obtain a consumer.

The city purchased the plant in 1917, since which date we have laid mains in all the streets in the older portion of the city and have done away with these small services. We insist that each service enter the premise from the front on the street on which the house takes the number.

We make no attempt to keep a record of the exact location of the service other than that of the meter box. The meter box is set at the curb and the service pipe is laid at right angles direct to the main. A record of the size of the service, number of feet and material used, together with the size of the main and nature of street paving is made on 3 by 5 cards and filed in a card index cabinet according to street and location. No record other than house number and street is kept and if the owner desires to know anything about his service he gives us his house number and street and by referring to the card index system we can give him the complete record of his service. Our object in filing according to house number and street is obvious, in that we do not have to keep changing our records for property changes.

JAMES WOOLLEY: I might say that in the City of Newark, N. J., when we put a line through a street, we always put the service to the curb, but, before doing that, we notify the property owner that we are about to put a main through the street and he is supposed to designate whether he wants a service every 25 or 50 feet, whichever it may be. We put the service in to the curb and we maintain it so

that when he is ready to build, all he has to do is to make application. We do not allow people to come along afterwards and rip up the street to get a service. A newly paved street cannot be opened up in less than five years; they must notify us when the service is put in.

Fred D. Manville: In Newport News we put them in the center of the house, if there is a house on the lot. If there is no house we do not put in a service.

William W. Brush: In New York City we require that the service shall be laid from the main to the building on a line at right angles to the main or to the street line, where the tap is located, the nearest intersecting street curb line. That informatin, together with other data, is placed on the card, so that every tap has a card. Unfortunately that has not always been done in the past and we have a good many thousands of services where we have not such a record, but, for many years past, such a record has been kept. I believe that those who have to put in services would find it worth their while to make an accurate record of the service, which will very possibly not be used for the next twenty years, but thirty years from now it will be very useful to know just where the tap is in the main.

(No curb box is used in New York City—*Editor*.)

W. S. Cramer: About four years ago immediately after quite a large fire in Lexington, I was very glad we did have street measurements. We had one, two, three or four $\frac{5}{8}$-inch services all buried under 5 to 15 feet of hot brick, and were able to get to them in the course of two hours.

Dow R. Gwinn: I think it is important to have a record of every service. When I went to Terre Haute, we had to call in, first one man, and then another, to ask him where the main was located and get what information we could, but what I was afraid of was that these men might die in the course of one hundred and fifty years and there would be nobody to give us the information.

Every application that comes in has a number which never changes, and we have an envelope, about $4\frac{1}{2}$ by 9 inches, and each envelope has a number corresponding with the application number. On the outside of the envelope is a printed form for the location of the corporation cock, distance from the property line and from the nearest

street at right angles, and also the location of the service box and the size of the service. Then inside the envelope we put the report of the foreman who made the tap, the men who worked on the tap, the location of the main in the street, the size of the main and the depth below the surface. With that information we were able to make out a street record which was fairly complete. Now when a man comes in and wants to know about a service, all he needs to do is to give us the number of the street and we can turn to that application number and give the information he wants.

W. S. Cramer: In helping to rebuild one of those old southern towns, I should like to tell you that I took the property line just as you have done originally. I had to go back and change it and go back to the original property line of the street and measure from the street intersection rather than the original property lines. Your property lines are changed so that they would be of no use whatever.

James E. Gibson: In connection with old services, we use the electric pipe locater. In a number of cases we have found two or more services entering the same property. In a few cases we had metered one of these services and only discovered the other by accident or when someone got into trouble. Our experience with the pipe locator has been very satisfactory. We have located service pipes 2 to 3 feet under ground, when there were no records in the office or no memory of any such service having ever been laid.

THE USE OF POWER OR GASOLINE PUMPS FOR TRENCH WORK

William W. Brush: The gasoline pump is part of our regular yard equipment. Each repair company has one or more diaphragm pumps driven by gasoline engines. I saw in Philadelphia what impressed me as being a mighty good scheme. There they have taken a Ford chassis from a car that has served its time and was to go to the scrap heap, stripped it and then mounted a gasoline diaphragm pump on this chassis with a light steel frame, a canvas cover and a tool box. This outfit is used as a trailer, taken on the job and can readily be moved by hand. I was told that old pneumatic tires were put on the wheels so that this pumping outfit could be left out without any attendant over night. They are more honest in Philadelphia than in New York, because I do not think there would be any pump, tire, chassis or anything else left in the morning, if we left such an outfit out on the street.

LAYING WATER MAINS OR SERVICES IN TRENCHES WITH SEWER PIPE

William W. Brush: In New York, we lay the water main in the sewer trench, and the service pipe is laid in the sewer trench to the house. Rock is difficult and expensive to remove. The laying of the pipe in the sewer trench has not caused us any particular trouble. We have more trouble with our rock filled streets than we do with our streets where the pipe is laid in the sewer trench, and by using the sewer trench it has reduced materially the cost of installation to the city and of the service to the community. Where rock is at the subgrade of a street, the cost of removing that rock is a large item. While there are some obvious disadvantages in this practice, we believe that the advantages outweigh the disadvantages. The practice is one that we expect to continue.

Our main has a 4-foot cover, and I should judge that the sewer must be about twice as deep. The water mains are laid on the back filling of the sewer trench. I should state that we do not lay the water pipe at the same time the sewers are being laid. The water pipe is usually laid several months or several years after the sewer has been installed and, therefore, after the ground has had a chance to settle.

Warner C. Brockway: I should like to ask if that is for general construction or is it just where you have rock excavation?

William W. Brush: It is only where we have rock excavation. We have definite distances which vary in each borough as to the distance from the curb to the water main. We have considered making the distance uniform, but we found that that would not be helpful because all other subsurface structures are laid out in relation to the water main, and the result is that each borough has its own regulations as to the distance to the curb for the various subsurface structures, the telephone ducts and the electric light ducts and sewers all have their particular location, and we do not attempt to make uniform the distance from the curb to the water main in the

different boroughs. That distance varies from six to nine feet from the curb, and it is only when we have rock that is virtually to subgrade of the street that we put the main in the sewer trench; otherwise, it is laid at the usual distance from the curb.

Warner C. Brockway: Is your topography such that your sewer line does not conflict with the water line?

William W. Brush: The sewer line is always below the water line, so it does not interfere in any way, and at the manholes our sewer trench is wide enough so that we can lay by the manholes as a rule without deflecting the line of the pipe.

A. V. Ruggles: On the subject of practice as to laying water mains in sewer trenches, the rule in the Cleveland Water Department, also followed by our orders in all suburbs which we supply with water, is to lay water mains and sewers in separate trenches in the street in all cases. House connections for sewer and water are laid not closer together than 5-feet center to center, except in rock excavation. In the case of rock excavation we permit a ledge not less than 8 inches wide to be cut horizontally in the side of the sewer trench and on this ledge the water connection is laid. This brings the water connection not less than $1\frac{1}{2}$ feet higher than the sewer connection.

THE WATER WORKS COAL PILE[1]

J. W. TOYNE: There are two points that the speaker brought out that attracted my attention. One thing was how essential it was to have an intelligent boiler room crew. I believe ours is barely good enough. If there is any scheme for securing that, I believe it would be of interest to everybody. Another thing, along towards the end of the paper he made a comparison between a municipally owned and a privately owned plant. I should not attempt either to deny or to clarify that except in one instance. I can point to a municipally owned plant that is operating largely on Indiana screenings, and that is operated slightly below the half ton.

W. S. CRAMER: The Milwaukee plant is municipally owned. That is the best we have on record.

DOW R. GWINN: I think we are under obligation to Mr. Maxwell for the tables he has prepared. I am sure they will be read and studied with interest by the members. I happen to know of another municipal plant run on the private ownership plan in Iowa.

W. S. CRAMER: I want to say if you have never tried the bonus system to cut your coal cost down, try it and see how it works. I have been doing that for a few years now, and we have been getting some very good returns for it.

HENRY P. BOHMANN: Do not forget Milwaukee next year. We are putting in mechanical stokers and other new improvements which will be used by men who have been accustomed to hand firing for thirty or forty years.

CHARLES S. DENMAN: Since Mr. Maxwell obtained his figures we have installed at Des Moines a coal crusher. We grind our coal to a uniform size and estimate that this saves us about 5 per cent. The finer we prepare the coal, the better combustion obtained. The amount of combustible material in the ash is also reduced. When large pieces of coal enter the grates, holes in the fire develop which allow more air to enter than the gases will consume.

[1] Discussion of paper by this same title, by D. H. Maxwell, Journal, November, 1923, page 1072.

COPPER SULPHATE TREATMENT FOR ALGAE TROUBLES

GEORGE W. FULLER: I do not carry those figures very well in my mind. There has been lots of practical information obtained, and I believe it is something that is well worthy of record. Varying temperatures and varying conditions of water call for different treatment. Different kinds of organisms call for different treatment. I believe copper sulphate has a distinct field of usefulness and can be used to great advantage. It would be a good idea to get out a questionnaire and summarize the latest information.

W. S. CRAMER: The use of copper sulphate, like a lot of other things, is so cheap and it is so hard to handle without getting more than the prescribed dose in, that it is pretty hard to handle it under one part in four million, and we try to get it down as low as a part in four million or a part in two million. It is awfully hard, even with a fast motor boat, to get your distribution over the entire surface when using very small quantities.

GEORGE W. FULLER: As I have visited works where growths are very objectionable as to tastes and odors, I find there is quite a difference in the way in which water departments function when there is need of using copper sulphate. In some places they always keep on hand an adequate amount of copper sulphate, and there is always some person delegated with authority to apply that copper sulphate quickly. There are other instances where copper sulphate has been needed very badly indeed, but they have not done so. There also seems to be a marked absence of adequate authority in some places for some one person to go ahead when conditions call for prompt action. These are two striking lapses I have run across in securing the benefit of copper sulphate.

W. S. CRAMER: If the man in charge of your filter plant has direct charge of that chemical, the same as the others, the filters will soon tell him when it is necessary to use it. There is one thing those who are interested in the copper sulphate treatment should take up, if

you have not already taken it up, and that is to watch the shallow nooks and small pools that are found and will flush after a rain, and dose them at least two or three times in between the times of your regular doses, and keep that growth down. That is where your growth comes from, you may kill the growth in the main body, but those nooks are incubators, and they are continually starting a growth in the main body. We have two spring branches that come into our reservoir, and I have a small paddle wheel and there is a sack on that paddle wheel, a very closely woven sack, and we fill that sack three times a week and it about exhausts the amount we put in there in two days. That takes care of the pools formed by these spring branches coming in where they connect with the main reservoir, and it keeps those pools very sightly. Before we adopted that treatment, they were continually covered with a green scum. They are along the main driveway and very close to the entrance to our main pumping station, and that treatment has kept them down very nicely. You want to watch all the main breeding spots and dose them much more heavily than the main body so that they will not propagate and come over into the main body.

William H. Lovejoy: Our chief difficulty at Louisville has been the shortening of the filter runs due to presence of microörganisms of different types, principally the diatoms Melosira and Synedra. During the past fifteen years we have experimented in the dosing of the water in our settling basins with copper sulphate, using varying doses of copper and different methods of applying it, in order to find the best method of killing the growth.

No amount of copper sulphate or method of dosing has ever proven entirely satisfactory to us in bringing the filter runs up to a normal length. We formerly used weekly doses of about one part per million of copper, but we are now using two or three doses weekly at a strength of one-half part per million and find that this smaller and more frequent dose gives better results on the filter runs than the larger dose.

The smaller dose of copper also has the advantage of causing less aftergrowth of bacteria in the filters and clear well. There are times, however, when neither a large nor a small dose of copper seems to do any good. This is probably due to either some peculiar combination of organisms being present or to unusually large amounts of amorphous matter. At such times our filters often run as short as

one or two hours. Such short runs obviously cause great operating difficulties.

Our algae growth is really a river growth and not a reservoir growth. For this reason it has to be treated differently than is the case with a purely reservoir growth. With a reservoir growth, the reservoir may be cut out of service, treated with copper, allowed to stand until the organisms have disappeared and then the water may be run onto the filters with safety. In our case, however, fresh organisms are being constantly added with the daily pumpage, making it necessary to treat the water continuously or at very frequent intervals. In the seventy-two-hour settling period in the reservoirs the count of organisms seldom increases more than 5 or 10 per cent above the river content.

Previously we used to treat one reservoir at a time and cut it out of service for two or three days, but we found that this method did not give good results. At present, we are using the method of treating both basins at the same time, adding half a part of copper at the inlet of each basin over a period of eighteen to twenty hours. Diffusion is very rapid in the case of copper sulphate, and we find that this method is much easier than that of dragging it in sacks from a boat and also the distribution is just as good as in the latter method.

Our settling reservoirs hold about three days' supply, one hundred million gallons against thirty-five million gallons daily consumption.

James E. Gibson: Our impounding reservoir holds something like three billion gallons of water. The average depth is about eight and one half feet, and the total area flood is a little over three square miles. With our warm climate the conditions for algae growth are ideal. When Mr. Bunker was at Charleston in charge of the City Laboratory he made a catalogue of the algae in our impounding reservoir, and, as I recall it, this catalogue was a list about 2 yards long. We do not attempt to identify the various growths as they all look alike to us when it comes to treatment. We use about 100 pounds of copper sulphate per day from the first of May until the middle of October, and use three methods of application: first, trail it from the stern of a boat in the large reservoir; second, we suspend in our intake a small amount in a gunny sack, with a cotton rope, that is allowed to dip to the surface of the water; the capillarity of this rope brings sufficient water to the copper sulphate to dissolve it so that there is a constant dripping of the solution into the supply

going to our low service pump; third, by the same method we introduce small amounts in our sedimentation basins which are two in number, the water passing through them in tandem. The copper sulphate solution is placed at the entrance of the water in each of the basins.

Occasionally, to stop the growth of algae in our clear water basin, we introduce in the main effluent from the filters a small amount of copper sulphate which we feel effectually stops the growth of algae in this basin. Our worst condition is in the fall of the year when the weather turns cool and the algae begin to die; the most aggravated period is when the water in the impounding reservoir turns over.

E. T. Cranch: At Petersburg, Virginia, we obtain our water from the Appomattox River, and have practically no algae to start with, but we have a three million gallon equalizing reservoir to which the filtered water is pumped and exposed to the hot sun. Here the algae develop rapidly. In previous years, every summer there was considerable complaint made about the taste of the water. Two years ago I started treating this reservoir with about three-tenths parts per million of copper sulphate. At this time we had no equipment for making a microscopic examination of the water. We received no complaints regarding the taste of the water until late in August, when some trouble did develop. Last year I started making microscopic examinations of the water and found that on the day after treating the reservoir with three-tenths parts per million of copper sulphate we still had an active algae growth. I then raised the dose to six-tenths parts per million and found that this eliminated practically all the algae, as I had no active growth after this treatment. I found that it took about two weeks for the algae to develop to any extent, so that I adopted the practice of treating this three million gallon reservoir every two weeks with 15 pounds of copper sulphate. We apply the copper sulphate by simply placing it in a burlap bag and dragging it from side to side of the reservoir. Since adopting this method of treatment we have had no further complaints regarding the taste of the water.

Fred D. Manville: In Newport News, we treat water, when it is needed, for crenothrix, and sometimes anabaena. This is determined by close observation of the water. We have used copper sulphate at the rate of two pounds per million gallons, but since the last

convention we have discovered that pretreatment with liquid chlorine seems to do away with the need of treatment with copper sulphate. That is, the water is treated with liquid chlorine and alum into the suction of the low lift pumps, then it goes over the aeration system into the coagulating basin. We are now using pretreatment with liquid chlorine in all of our water, as we find it does the work better, with better coagulation, and the amount of alum required is materially reduced. It is our intention to continue to treat the water this way the entire year.

We have used this pretreatment as high as 8 pounds per million gallons of water which was in bad condition, and after filtration we used 4 pounds per million.

Francis D. H. Lawlor: From what Mr. Lovejoy has said, I think his conditions must be very similar on the Ohio to the condition which Mr. Henderson has at Davenport, on the Mississippi. The intake comes into his plant from the river, and as I understand it, the settling basin has a capacity of about five million gallons, and instead of treating it with copper sulphate, he uses liquid chlorine, and his dose of liquid chlorine, if I remember his figures, is between 18 and 20 pounds per million gallons. He applies it in the fore bay and then this water goes through pressure filters, and they claim at Davenport that they get no taste or odor from the liquid chlorine with that 18 or 20 pounds per million gallons.

At our plant at Burlington, we never observed algae in the water until perhaps three or four years ago, and perhaps our troubles are not as serious as those at Davenport, but we simply get clear of the algae by more frequent washing of the filters; perhaps we double, roughly speaking, our percentage of wash water and wash it out, but we have gravity filters and are able to do that. Not having observed the water until a few years ago, I formed a theory that perhaps the algae were coming to us from the new drainage districts. The water stands in the old sloughs or swamps behind the levees and at certain times is pumped into the river. I had a theory that the algae were coming from these places. I do not know whether it is true or not; I have not been able to confirm it. If any of the gentlemen are interested, if they get in touch with Mr. Henderson, he will be able to give them further information.

ALEX MILNE: I had a little experience a number of years ago with algae growths. Our reservoir at St. Catharine's, Ontario, has three sections comprising a storage of 364 million gallons. At that time it was taking care of a storm water outflow of about twelve thousand acres. The upper section of the impounding reservoir had become almost filled up in the wash from the storm water in that area, a convenient spot for algae growths. Before having time to study the matter, we treated it in a crude way with copper sulphate for a couple years without very much result. On my recommendation the Board authorized me to clean out the upper impounding basin. We reduced the area about one-half, created a depth of 10 feet of water at the foot of the slope wall, cut out all possible chance for growths in that section, and then at the intake created a fan tail aerator and aerated all the water coming in, and that being too small for our consumption during peak period, we installed a 24-inch main at the lower end of the reservoir and put in a jet atomizer for the additional supply when required. The difference was immediately noticed. On examination of the water we found that we were liberating, destroying or letting loose a great deal of algae. If you stood on the windward side of the jet, you would think from the odor it was all let loose; we reduced the content by 65 per cent. We did not reduce it entirely, however, until the following year by a diverting canal diverting all the storm water from the reservoir, and then we got rid of all our algae. In the remarks of one of the speakers, it struck me as rather peculiar that he was destroying his algae by the use of chlorine. I did not find it very efficacious. The moment I started to use chlorine in conjunction with the algae I got the combined taste and odor of the two. Our consumption downtown was reduced 50 per cent, nobody could use the water. The moment you attempted to drink a cup of tea in the morning you would immediately grab your nostrils and walk off and leave it alone. I do not see where the application of chlorine would be justified as a reducer or eliminator of the algae taste.

E. E. DAVIS: We had a sad experience with algae in Richmond, in June, 1914. The water that supplies our settling basins is taken from the James River, at a point one mile up the river. There is an island, and around the upper end or point, the water flows to the feeder of the sedimentation basins. Near the lower end of this island there is a diversion dam which gives us a head for the feeder. The

rest of the water of the river flows down on the south side. The river was low at this point, and at times there was no water flowing over the diversion dam. At this time the Board of Health reported some 27 cases of typhoid fever in the city. I took the matter up with Mr. Beck who was a member of our Administration Board and an engineer, and explained to him what the trouble was, lack of fresh water. After looking over the condition with him he offered a resolution to our Board instructing the Superintendent of Water to do what was necessary to remedy the trouble. I built a rubble dam from the island to the southern shore of the river thereby diverting as much water as possible to the north shore of the river. By so doing the water was raised high enough to flow over the diversion dam on the north shore, thereby getting a good flow of fresh water into the basins. We sometimes find algae in the sedimentation basins. We use copper sulphate or blue stone by filling bags and fastening them on a boat, so as to drag them under the water.

J. M. Diven: The speaker's experience in copper sulphate treatment has been long and varied. Very soon after Drs. Moore and Kellerman gave this valuable information to the world, a reservoir of which I had charge developed algae trouble and Mr. James M. Caird, who at the time was in charge of the filter plant at Elmira, New York, applied copper sulphate to that reservoir. At that early day we probably lacked confidence and were very cautious. I remember that I insisted on not using the treated water for several days after the treatment; fortunately we had another source of supply. In fact, the reservoir water for some time before the treatment had not been fit to use. The treatment was entirely successful, and that reservoir has been copper sulphate treated many times since.

My next experience was with a large and shallow reservoir in the South, where algae are active ten or more months each year. The reservoir covered some 2000 acres and had an average depth of about 8 feet. We first attempted to treat the entire reservoir, paying particular attention to the shallow places, the little inlets and bays. Algae grew rapidly and were very thick in such nooks and the idea was to destroy it at its source. But the surface to care for was large and such treatment proved very expensive. Afterwards, this water was treated near the pump intake in a radius of 500 to 1000 feet. Some additional treatment was given in the intake, where a very

small quantity of copper sulphate was applied. Mr. James E. Gibson has fully described the treatment of this water. His treatment is practically the same, except that we did not treat the water in the clear water reservoir, never having had any trouble with algae there. When cleaning this reservoir, however, we washed the walls with a rather strong solution of copper sulphate and also with a solution of hypochlorite of lime. After this washing the sides were washed down with strong hose streams to remove any surplus of the disinfecting solutions used.

My next experience was with a large and deep reservoir in the North. The reservoir had a capacity of eleven billion gallons and a maximum depth of 58 feet. Algae gave trouble only for a short time in the summer. The shores were mostly abrupt with few hiding nooks for the algae and the treatment was mostly in the shallow places where the algae began to form, killing at the source. Owing to the large surface to be covered it was found advisable to use a motor boat. This hurried and cheapened the work, requiring less men and considerably less time. It also made the application more effective, as it kept the water that was being treated well agitated, helping the mixing of the solution. We had an idea that much less of the copper sulphate was coated with sediment in the water and carried to the bottom, we got more benefit from the amount used and possibly might have reduced the quantity applied, but no experiments were carried out to determine this.

Some fish were killed in all cases. All three reservoirs were stocked with black bass, but the fish killed were mostly bullheads, suckers, carp and other mud fish. Very few bass, pickerel or other game fish were affected. This is possibly due to the fact that the treated water is harmless, but that the mud fish got the copper sulphate that had settled to the bottom, as it is their nature to root in the mud bottom.

STATE LICENSES AND TRAINING SCHOOLS FOR FILTER OPERATORS

Dow R. Gwinn: I understand that the state of Texas requires filter operators to have a license; they put them through a regular examination before they are allowed to operate filter plants. I do not know that any other states require licenses for filter operators.

John Chambers: The State Board of Health in Kentucky is quite active and a bill was introduced in the last legislature giving the State Board control of the design, construction, maintenance and operation of all plants, whether municipally or privately owned. The bill was defeated. The Louisville Water Company opposed that portion which provided for the control of the design, construction, maintenance and operation, but invited such examinations of the water delivered to consumers as the Board of Health should see fit. Of course there was a great deal of opposition from privately owned companies. I do not see how it would be possible, except perhaps in the eastern states, to provide a training school for filter operators. I mean the men who actually operate the filters and not the chemist or bacteriologist. The Louisville Water Company's chief chemist and bacteriologist has control of the treatment of the water. He is a man of excellent executive ability and technical knowledge. The filter operator must serve an apprenticeship before he can be left in charge of operation. Of course, any preliminary education which he might obtain would be helpful.

Francis D. H. Lawlor: We have comparatively few filter plants in Iowa. The filter plants are mostly in the southern counties of the state; in the central and northern parts of the state their water supply is mostly from wells, so it is not a live issue in our state.

W. C. Hawley: No license is required in our plants in Pennsylvania at present. Our plans and specifications have to be approved by the State Department of Health, and the State Department keeps a close watch on the operation of the plant and on the results. We report weekly.

ALEX MILNE: There is no license required in Canada and no instructions are required. The Provincial Board of Health at Toronto, the headquarters, have a laboratory with a filtration plant, rather in miniature, installed there, and the recommendation of the Provincial Sanitary Engineer is that in the event of a new filtration plant being installed on a city service, that their services are given gratis to training any operators you send to them. I would rather imagine from Mr. Dallyn's action that it will not be very long before training is required for filter operators. It is leading that way now.

GEORGE W. FULLER: In New Jersey they are required to be licensed for both water and sewage purification works.

DOW R. GWINN: Good; that makes two states.

A. V. RUGGLES: In reply to the question as to whether filter operators are required to be licensed. A license is not required in Ohio. The engineers of the State Department of Health make periodic visits to the several hundred filter plants in the state and do a great deal of good, spreading the gospel of best operating practice and new methods and discoveries. The Ohio Council of Filter Plant Operators holds a meeting every year, which is very well attended and valuable, and where excellent papers are presented and open discussion is had on matters of filter operation.

E. E. DAVIS: We have a Supervisor, who is a chemist, at our settling basins. He makes a daily report to the Director of Public Utilities, our boss, one to the State Engineer, who looks after all the purification plants in the state, attached to the State Board of Health, one to the Director of Public Welfare, our city's Health Department. They check him up. I know of no state law requiring a license. Our plant is one of the old style sedimentation and coagulation. We have under construction an up-to-date filter plant, of 30,000,000 gallons daily capacity which we hope to have in operation by the first of July, 1924.

SERVICE PIPES: WHO PAYS FOR INSTALLING, REPAIRING AND MAINTAINING?

WARNER C. BROCKWAY: The standard water service in use in Duluth, Minnesota, is ⅝-inch lead pipe. Lead pipe ½-inch in diameter is the absolute minimum sized pipe that will be installed. Larger sizes will be put in, in accordance with the schedule of higher prices, if the consumer so wishes.

Originally gas services were made of one inch iron pipe. When renewals are necessary, 1¼-inch galvanized iron pipe is used. The original cost of service connections is paid by the consumer. Renewal of connections is at the expense of the water department. A renewal is better than an original service that the consumer has paid for, which constitutes a burden to the water department.

Instances are on record where services installed have not been used, so that no revenue for water has been received by the department. When such services must be renewed, it is clearly a financial burden to the water department. The connections extend from the main to a point one foot inside of the curb line.

The basis for the charge for the house connection made by the water department is from the center of the street, even though the main may be located on one side of the street or the other. In some cases, of course, the city loses money, but in other cases, the city makes money. It seems that this method is equitable for all concerned. If a water service line only is installed, the cost is $1.80 per foot. A charge of $2.00 per foot is made when both gas and water services are laid. Rock removal and paving charges are added.

The work of laying pipe from the curb line to the house fixtures must be done by a plumber, hired by the owner of the property. The water department inspects the work of the plumber to the point where the meter is installed. The question arises as to who should pay for the added cost of the renewals over the cost of the original service.

OSCAR E. BULKELEY: I should like to bring up another point regarding services, namely, installation of services ahead of pave-

ments. This is becoming a real burden in many cities on account of the large paving programs which are being carried out. In Lansing the Water Board pays for the cost of installing all services up to the curb box. Every lot is given service before the street is paved. Often there are a great many vacant lots, and, therefore, services after installation remain inactive, many of them possibly for a number of years. When finally there is a demand for this inactive service it may not be found large enough or it probably is not in the right place. There are a number of indefinite things about such installations, so that the speaker has questioned the advisability of installing services for all vacant lots ahead of new pavements. I should like to know what the experience and practice of others has been.

John Chambers: I think we have an aggravated case of that kind in Louisville. There is an ordinance, using the language of the city charter, which provides, before a street is constructed, that every lot must have installed a water, gas and sewer service. A notice is served on each property owner allowing him twenty days in which to secure the service. If he does not comply with the terms of the notice, and he is not compelled by law to do so, he cannot secure a permit for disturbing the street pavement for the installation of any kind of service whatever until the five-year guarantee period on the street pavement has expired. Many complications result. The Louisville Water Company usually installs most of the water services as there is no charge for the installation whatever. If, however, the service does not yield revenue at the end of one year the owner of the property for which the service was installed must pay to the water company the cost of the installation. Requests for services that were not installed before the construction of the street are quite frequent, and in some cases very appealing, people having purchased lots on which to build homes only to find out that water service cannot be obtained.

F. A. Bunks: In the laws of this state (Michigan) is a section which may be of benefit to the gentlemen. I refer to paragraph 3094, Section 8, of Compiled Laws, State of Michigan. Briefly, all persons owning lots, land, etc., adjoining to or abutting upon any street, avenue, etc., before same shall be paved, shall lay all sewer, water and gas connections and carry same beyond the curb line as

the Council shall determine necessary. Should the owner neglect or refuse to make, lay or put in such connections at the time and in the manner prescribed by the council, then the council shall cause the same to be made. The respective owners of such lots, etc., shall be liable for the cost thereof together with a 10 per cent addition thereto as a penalty. The cost and penalty may be recovered by the city in an action of debt of assumpsit, or shall be reported to the Board of Special Assessors, to be levied and assessed by them as a special tax or assessment upon such lots, etc.

Oscar E. Bulkeley: There may be such a law; it was, however, referred to our City Attorney who evidently was not aware of the existence of such a law.

W. G. Patterson: The gentleman is right on the law in regard to installing services and making assessments, because in Highland Park we install services on all vacant lots before the pavement goes in, and if they are not paid for within one year there is a special assessment and we collect it with the other city taxes just the same as we would a paving tax or a sidewalk tax. It becomes a lien on the property.

John Chambers: In our case (Louisville, Kentucky) it is not a lien on the property.

J. N. Chester: It is a local question and depends on whether it is a private water company or a municipality. The Pennsylvania Public Service Commission says to all private companies, "You must lay to the curb line at your own expense, the service, furnish the shutoff cock, and if the city or borough want to charge you for taking out a permit, you must pay that." But I live in the city of Pittsburgh and they would not even furnish a corporation cock. I paid for everything, including the corporation cock being put in. Some cities have ordinances requiring the property owners to put the services in ahead of the paving, and some cities have ordinances making the water companies put services in ahead. I do not believe in putting services in ahead, I had one experience at Lyons, Iowa, where services were required to be put in ahead of pavements, and instead of the town growing up to the pavement, it went back and hundreds of services stood for years unused, and then leakage set

in and they all had to be taken out. But I think it is a local question depending on the state laws, city ordinances and municipal or private ownership.

OSCAR E. BULKELEY: The expense must be borne by some one. The speaker was informed by Mr. Brush that in New York services are not placed unless a consumer is already assured; if uncertain, the pavement is placed and later on the consumer pays the extra cost of installing the service on account of digging up and replacing the pavement.

Answering Mr. Chester, that may be local to New York, nevertheless the expense of installing a great number of services is saved. They are not installed until actually used. This matter is of vital importance to every water works, whether privately or municipally owned.

J. N. CHESTER: If it lies there idle ten years, it will cost 100 per cent more.

OSCAR E. BUKELEY: Surely, and looked at in that light, it would seem better not to install such services previous to the laying of pavement. The larger economic aspect of the problem should be considered. Perhaps also the psychological effect of continually excavating through comparatively new pavement is also important and perhaps is difficult to measure in dollars and cents.

W. S. CRAMER: We have a considerable development in Lexington, Ky. In fact almost all our development now is just outside the city limits. We started three years ago on a new proposition of running the water main in the parkway between the sidewalk and the curb stone, and it was provided in the deeds to the property that we had the right to dig up in front of your house to tap the main for across the street and use a pusher to go under the street. Our soil is fairly heavy clay and this provision worked out very nicely. We have one residential district that has something like 22,000 feet of pipe, and I should say today it is 80 per cent tapped. We have no trouble tapping and it has gotten us away from putting the service in ahead of street pavement. We had developed prior to that inside the city, and I think on something like 250 taps that were put in, we have 37 there now that will never be used. In selling the lots

in that locality, I do not know whether that is customary elsewhere, the lots are all 25 foot lots, you cannot buy less than two, but you can buy as many as you want on a bid on the price per foot. You bid on a lot, say $30 a foot. You cannot take less than two lots, but you can take three or four or five, and in bidding that way we have some houses that were built on 60 foot lots, some on 75 and some that have gone the extreme the other way and put two bungalows on a 75 foot lot. In that way we lost 37 taps in that one development. It is occasionally possible to run 15 or 20 feet from that tap to strike another man's property line, but you still have the tap in front of the other man's lot. It is not regular or desirable in any development of that sort. In the change of the frontage a man finally uses, you have a number of taps that will never be used.

W. C. Hawley: It seems to depend on whose bull is gored. If the municipality has to foot the bill they do not put them in; if the property owner or the water company has to foot the bill, they are ordered. I had an experience a few years ago, when the railroad tracks through the town were raised and some of the streets depressed and permanent pavements laid in those streets. The borough authorities ordered us to put in service lines in front of all vacant lots. We told them we did not put in service lines, that was up to the property owner. The property owners had more votes than the water company, so they decided that the borough would put in the services. The borough authorities decided where the services should be put in, the size, etc. Since that time a great many of those lots have been built on and there were just two of those service lines that were in the right location and of the right size, the rest were too small or were not where they were wanted. Recently our company began to put in service lines without charge to the consumers. The borough is doing some paving and we have been requested to put in service lines. After discussing the matter, we are putting in some lines where we know they are going to build. In some cases where we do not know whether a building is going up or not or what kind of a building or what size service they are going to need, we have compromised on this basis; we put in a six inch sewer pipe, and then when necessary to put in a service line, we can dig down to the main, put in the corporation cock and put the service pipe through the sewer pipe to the curb, whatever size is needed. In that connection, we are putting all our service lines now through sewer pipes so that

when the permanent pavement is put down it will not be necessary to tear up to find a leak, the water will come up through the curb box and we can then go to the main, disconnect, dig down to the curb stop, pull the pipe out at the curb, fix it and put it back.

Answering Mr. Cramer's question, the sewer pipe is as expensive as service pipe, but it will be cheaper than tearing up the pavements and we hope to avoid the criticism which tearing up the pavement causes.

W. S. Cramer: If they let me go to the main, I will get the service in all right; we can put them in with a pusher if they let us go to the main.

W. C. Hawley: We cannot do that in our soil.

W. S. Cramer: Not long ago a friend of mine came to me and wanted a service put in. I said, "Have you got any particular place to put it?" He said, "Yes, I want to put it on the south side of the lot." I said, "You had better put it in the center; you might change your mind about the house." "Oh no. I am going to put the house on the north side of the lot." We put in the tap and in a few days he came back and said, "You will have to move that damn tap; I took the old lady out there and she changed *our* minds; we are going to put the house on the south side of the lot."

J. M. Diven: Mr. Cramer spoke of running the water main in the parkway, between the sidewalk and the curb. But this space in residential districts is usually occupied by shade trees and digging to the main to make a tap or repair a leak is apt to disturb, injure or possibly destroy a shade tree. Shade trees are something dear to the heart of many people and they resent any injury to them, in fact in many cities they are protected by ordinance. I vividly remember an experience with a water main laid in this way when a lady appeared with a dog and shot gun and ordered us not to disturb her shade trees. In this case the leak was directly under a tree and it was necessary to tunnel under the tree roots to get to it. We abandoned the work until our attorney could reason with the irate lady and explain the situation. I did not in the least blame the lady for her position, for the tree was a very beautiful one. We finally managed to repair the leak and save the tree, but it proved an expensive job.

I do not think it is usual to put services in ahead of a pavement on a basis of 25-foot lots in residential districts, for it is seldom that so narrow lots are sold or built on. Even on a 50-foot basis they do not always hit the right place, even if they happen to be the right size. I remember an occasion where services put in for 50-foot lots proved wrong, as the 100-foot making up two lots was finally divided and built on as three lots. In this case two services were joined just inside the curb line, and third service taken off the connecting pipe. This tided over the difficulty and saved digging up the newly laid pavement. But, though there was a distinct understanding with the three property owners about the care of the two services from the main, including an agreement between them as to ownership, I can see possibilities of trouble some day.

One more word on services put in to save tearing up pavements and before the property is improved. These services are necessarily "dead ends" and have no circulation. After an unusually severe winter at Troy, New York, when the frost went below the depth expected and provided for, below the 5-foot mark, 55 dead services were found frozen in the spring and had to be dug up and repaired, disturbing the new pavement quite as much as putting in a new service of the size and in the location wanted.

Henry P. Bohmann: We aim to get in all underground structures in Milwaukee before putting down a permanent pavement. The last year a district was annexed to the city, and immediately we proceeded to put in water mains and sewers and bring the water service up to the curb. I was very much surprised to learn from Mr. Brush that this is not the practice in New York. In this particular district, the services were extended to the curb immediately before putting down the pavement. I do not think in this district that there will be a single lot without a house on it inside of two years.

E. E. Davis: In Richmond we run the sewer in the center of the street, the gas pipe on the north and east and the water on the south and west, and if a new pavement is to be laid the telephone company, the telegraph company and the power company are notified to put in their underground work. The city puts in the sewer and assesses the property ten cents a front foot on each side. The property owner pays for sewer connections. When the gas pipe is connected there is no charge for the connection, but there is for the water connection.

When a man comes and signs the book, he is required to return to us a piece of lead pipe the same length as we put in.

J. M. Diven: The south side of the street is all right in a climate like that of Richmond, but in the north the water main would be more comfortable on the north side of the street where it would get the benefit of the winter sun. I think those living in northern cities have noticed that the snow and ice disappear earlier in the spring on the north side of a closely built up street, as the buildings on the south side shade the street for a longer time each day.

Dow R. Gwinn: In Terre Haute we are required to lay the service pipe up to the curb at our own expense, provided a man will agree to take water for one year. In that case we maintain it and take care of it forever. In case of what we call improvement services, the city engineer goes over the street before the contract is let, usually with our men, and he decides where he wants laterals, as they call them, put in. We make out the list for him. Then he gives that list to the contractor, ordering the contractor to see that those services or laterals are provided before the street is paved. The contractor then comes over to the water works office and pays $7.00 for each one of the $\frac{5}{8}$-inch service pipes that are to be put in. He pays in advance, although he sometimes objects and says, "I do not get my money in advance," but he pays in advance. Then the lateral may lay there for ten or fifteen years without being used. That is the hard part. The water department or company has got to be responsible for that service pipe, keep it repaired and provide the water for the leaks, if any occur. You may not see them, but they are going on just the same, and in the meantime it may be fifteen, twenty or twenty-five years afterwards that somebody will connect to it and perhaps it may be in a wrong place, and nobody will connect on it. In the meantime perhaps they have had to resurface the street, so it is pretty hard to tell just what is the best thing to do. We dislike to see them tear up the newly paved street right after it has been paved. On the other hand, it seems a pity to allow the service connections to stand there for a long period of time and not be used, even though we do get $7.00 for it, for $7.00 does not begin to cover the cost.

CHARGES FOR PRIVATE FIRE PROTECTION SERVICES

Dow R. Gwinn: There was a gentleman here this morning, I do not know his name, and he said that he had compiled the water rates for private fire protection for 250 cities, and they went all the way from nothing up to $1000. Take your choice; I will take the $1000.

John N. Chester: I can say that I have compiled fire protection rates for 50 cities. For hydrants we charge the same as we charge the city, or in the city, in the municipal plant, we probably would not charge anything for hydrants. For the private company we charge them the same as the city, and they lay the pipes to the property line. For a sprinkler system, we charge the same service charge that we charge for anything else per opening, and we would not allow anything else to be attached to it. That service charge would not be less than $50 for a 4-inch pipe. For that service charge, we would give them sprinkler heads at the rate of 5 cents apiece, and if they have sprinkler heads enough to exceed the service charge, we would charge them 5 cents apiece for them. That is a general rule that may be modified to fit conditions.

Henry P. Bohmann: Ever since I have attended the water works conventions I have found this subject coming up each year. There seemed to be so much opposition to it that I almost got cold feet trying to introduce a charge of this kind in a city where this service had been furnished gratis for many years. I picked up courage, however, about two years ago and introduced a charge in the city council and it passed. We get $25 for every 4-inch connection, and $50 for every 6-inch connection. This gives an additional revenue of about $12,000 or $13,000 a year which we did not get before. With the first bill I sent a letter giving court decisions, railroad commission and public utility orders to justify this charge, and while I had two or three inquiries, everyone paid and we have collected the second year without any protest, so that up to the present time we have collected over $25,000 from a source from which

we did not get anything before. I anticipated a great deal of trouble, but it worked out very nicely. I want to say that all our services are metered except the automatic sprinkler. We have about 250 automatic sprinklers in service and it would be pretty hard to compel them to change to meters at this time, because I know the Association of Commerce would get busy with the city officials and I would have to stand alone. I know that I would go down to defeat.

Answering Mr. Chester, the consumer has the alternative of installing a meter and paying only the regular service charge of $20 per meter per year. The cost of installing a meter on a fire line is rather high so that the interest on the investment will amount to as much as our annual charge on the unmetered service. The annual charge really ought to be more, but it is one of the hardest things to introduce a charge of this kind where heretofore no charge was made. That explains why so many cities make no charge for this kind of service.

J. W. Toyne: The plant at South Bend, Indiana, is a municipal one, and for public fire hydrants we collect from the city $40 per hydrant per year. We make the same charge for private hydrants for fire protection, sprinkler, etc. We have a sliding scale or a service charge varying from $2.00 per month on a 2-inch line up to $10 per month on a 6-inch line. We make no charge for the water used in fighting fire. However, we do not allow any connections to these lines other than the sprinkler head.

W. S. Cramer: You will find as you go into this thing that most of this opposition and all this ammunition your citizens have to fight you with and the number of quotations they give you are furnished by contractors. A contractor will go to a man to furnish him a sprinkler outfit, and he will agree to put it in on the saving in insurance rates that it will make over a given term of years. If he can pinch you for any revenue, he gets by that much quicker, and he has got a whole armful of documents there and can show you where this place does not charge anything for installation or anything for service, glad to have them, welcome them. He picks those cases and he immediately gets busy. If this man is of a little prominence or has any pull, he gets busy, but when you fortify yourself and take with you that this is an outsider entering here and he is working for his own gain, it puts another face on the matter. It does not make

any difference to him particularly whether this goes over a longer period of time. The equipment man wants to get it over as soon as he can. If he can put it over in six years, why give nine? That is where most of the opposition comes from. It is the argument they give your citizenship in talking up the business.

Henry P. Bohmann: I should like to see all these services metered. The insurance men, however, go to the manufacturers and tell them they will not get as good a rate if meters are installed.

W. S. Cramer: I think you have done fine; you have talked to me about it before, and I think you have done fine.

Dow R. Gwinn: We have a minimum rate of $22.50 a month for a 4-inch connection for a private fire protection service. That rate was fixed by the Public Service Commission of Indiana. We allowed $22.50 worth of water for the minimum rate, so if the customer uses that much water his fire protection is not costing him anything. It is a pretty good thing to have a meter on private fire hydrants and be on the safe side.

John N. Chester: Are those inside their building?

Dow R. Gwinn: They were out in the yard, on their premises.

John N. Chester: If a man will steal water from his yard hydrant, he will steal it from the street hydrant.

Dow R. Gwinn: At one particular place, a meter reader went to read the meter and found a hose connection running inside the plant, and he said the hose seemed to be standing full all the way. We got $2000 from that man in one year, and he never complained. He used to complain about $20 a month, but when he paid $2000 a year he did not kick. Another concern paid us I think $700 the month before last, and their bill this month will be fully as great as the month before. We might as well get the money, there is no use furnishing those people water for nothing.

W. C. Hawley: I should suggest that Mr. Bohmann tap each side of the gate valve and put in a meter on the by-pass and without

anybody knowing it close the gate valve. You will not find all of them stealing water, but you will find a great many, so many that you cannot afford to furnish private fire protection without its being paid for. We tried it out the first time in Wilkinsburg, Pa., just to see what would happen. I induced our people to purchase an 8-inch detector meter. We put it on a private fire line and were surprised to find that water was being taken all the time through the by-pass meter. To make a long story short, we found that their large office building with all of its plumbing was connected to that fire line. When it was connected, nobody knows, nor how long water had been taken. In another case I tapped around the gate valve and tried it occasionally. We found at every test that water was being taken at the rate of $\frac{2}{3}$, $\frac{3}{4}$ or 1 cubic foot per minute, and even more. After a while we happened to get there at the right time and found that they were taking water at the rate of 4 or 5 cubic feet a minute. We put a detector meter on that line and we got a very handsome revenue from it. It was several years later before we found that they had a connection to those fire lines and were using water deliberately in large quantities at special times. Those are just two instances, but I can tell you of others. In these cases, as a rule, it is not the management that is responsible, but some plumber or foreman who needs a new water supply and taps the most convenient pipe.

Dow R. Gwinn: I am for the little fellow. We charge a minimum rate of about $1.00 a month. Where a man has a small house and does not require larger than a $\frac{5}{8}$-inch meter, we charge a minimum of $1.00 a month. If you will put the capacity of a 4-inch fire line meter along by the side of the capacity of a $\frac{5}{8}$-inch you will find that the capacity of one is a hundred and fifty times greater than the other. Now, if you charge the little fellow $1.00 a month minimum, what right have you got to let the other fellow off for the ridiculous sum of $5.00 or $10.00 a month? It looks to me as if he has that much capacity tied up with your pumping outfit and he ought pay somewhere near in proportion to what the little fellow is paying.

John N. Chester: You should have a graduated service or minimum charge, and impose it on all people alike.

Dow R. Gwinn: Away back in 1906 a certain manufacturing concern in Terre Haute started litigation in connection with a fire protection line, and he dilly dallied along with that thing until 1912. Then Mr. Chester came out and testified in the case and the court decided in our favor, that they had no right to demand fire protection except under special contract, and that we could shut the water off if we wanted to. We gave them a little opportunity to appeal the case and they did not appeal it, so we shut the water off, and in order to make it effective, we cut out a piece of the pipe. Then they appealed the case, and the Supreme Court decided it against us on our contract, because the contract said a man could buy water in such quantities as he desired, and on that little technicality the Supreme Court decided in favor of the plaintiff, that is, to this extent, the case was referred back to the original court for retrial. It was never tried again, because in the meantime we had a public utility law and the commission decided that every private fire protection line should be metered. We have a minimum rate of $22.50 a month on a 4-inch meter, and last summer we had another case with this same company. That time we got Mr. Cramer to come up and help us, and when the commission got through they ordered that the manufacturing company was not entitled to a 6-inch connection, that is, what they were demanding. We said we would give them a 4-inch connection, but we did not like to jeopardize the general fire protection for the sake of one concern, that our duty first was to the citizens and that the general fire protection was paramount, so the state commission ordered that we should not allow anybody to have more than a 4-inch connection unless we came before the commission and received special permission to allow something larger. Oh, it is a big problem, but the public has some rights that should be considered.

The committee appointed by this Association a few years ago went into the matter very thoroughly, and they cited, I think, about 15 cases where the water mains had been bled by the breaking of automatic sprinkler pipes; they also cited about a dozen cases where the public water supply had been contaminated through the private fire protection line, where they had their own pumping plant and forced polluted water into the mains, which resulted in quite a number of deaths, in one Illinois case. They cited a case where it cost the manufacturing company $100,000 through the compensation law on account of the deaths of its employees due to drinking the polluted water.

FRANCIS D. H. LAWLOR: It is a bit off the subject, but we had a little experience this spring. There was a very hot fire in a building that was not sprinkled. It was separated from a sprinkled risk by a 12- or 13-inch wall. The sprinklers in the building that was not on fire opened from the heat. It was a dry system and when those sprinklers opened, our engine ran away. I should like to ask if any of the gentlemen have had experience with their pumping engines starting to run away when the sprinklers open?

DOW R. GWINN: Yes, in our case it was due to the breaking off of the 6-inch line that the concern had at that time. The sprinklers did not put out the fire.

FRANCIS D. H. LAWLOR: Perhaps the sprinklers were the dry system and I thought that the air might get out through the sprinkler heads faster than the water, or perhaps when the check valve opened on the sprinkler system, the water in going in might create water hammer and compress the air, which surged back or something of that kind might have taken place. At any rate, the engineer on the watch reported that when these sprinklers opened, his engine started to run away. He was standing at the throttle at the time. We have direct pumping and the maximum speed governor shut the engine down during the fire, but of course the man was there and started it immediately.

DISCUSSION ON REPORT OF THE COMMITTEE ON METHODS AND RECORDS OF WATER WASTE CONTROL[1]

William W. Brush: In the Journal there has been printed the progress report of the Committee, and it is the desire of the Committee that the members read that report and give us the benefit of their experience in water waste prevention, water waste control, size of tap and services, etc. The report defines the various classes of waste and indicates the methods that have been followed in measuring and locating waste and in stopping waste.

We all know that waste exists in every water supply system. This country has developed rapidly and like all rapid growth it has been a growth in which much consideration has not been given to the smaller savings. Now we need to conserve to some extent and we are willing to conserve; perhaps not as willing as we should be, but the conservation of water is to be a more and more important question as time goes on and our water supply becomes more and more difficult to secure and more expensive. In the determination of whether water waste does or does not exist, the first question is that of consumption, and the really useful consumption figures are those that are most difficult to get. You can prove almost anything as to the consumption of your own individual community, if you will take the consumption figures throughout the country based upon the per capita and simply say, "Oh well, now here my community has a consumption which is such and such, and here are all of these other places that have a greater consumption. Therefore, we have a pretty good system." But that does not prove anything. You need to have your total night rate and your day rate; the night rate and day rate consumption of your larger consumers, the ones that use water for commercial purposes during the night hours, and compare the two and determine whether your night rate is down to a reasonable amount, when you consider the character of population you have to serve and the number of miles of main in the system.

[1] Report printed in Journal, May, 1923, page 468. Discussion at Detroit Convention, May, 1923.

If you determine that your consumption is too high, then it is a question whether it is too high on account of the waste of water inside the buildings or whether it is too high on account of leakage outside the buildings, or too high on account of both. If you go after the leakage outside the buildings, then you will either determine by pitometer the flow through the mains, subdivide your distribution system and find the suspicious locations and chase down the actual leaks which cause the high flow in those sections, or you may adopt the method of sounding and using an aquaphone to determine leaks. You may adopt the method of measurement of flow from hydrant to hydrant by closing a valve and using hose and meter to connect the two hydrants, or other methods. The methods mentioned are the more usual.

As far as waste in the building is concerned, you have the question of metering or examining the building and determining whether there are leaky fixtures and having the fixtures repaired. In addition to water waste control, your Standardization Council has seen fit to turn over to this Committee the question of the size of services, taps and meters. There are comparatively few data available in the published records of the transactions of the American and the New England Water Works Associations. It will be necessary to get from the different communities and the men in charge of water works just what they do in determining the sizes of taps and services. From the conversations I have had with superintendents, it seems to me that none of us have a very good method of determining the size of taps; it is "by guess and bigosh," largely bigosh, that we determine the size of a tap. Gradually the practice has changed so that five-eighths inch is virtually the smallest size tap that is used. I know in Brooklyn in years gone by the tap was made as small as the men in charge thought they could possibly get away with, and the service was made as small as possible. I asked one of the old hands why it was done and he said, "Well, we keep it that way so that we will keep as much water in the mains as we can." That is all right from the viewpoint of not having to go after more water supplies, but it is hardly service. I think we certainly should determine some reasonable way of getting at the size of the taps and the size of the service, the size of the connection to the house that will give to the occupant of the house good water service. That is what they want, that is what they need, and it is a mistake to cut down below the size that will give good service.

It does not mean very much leakage or loss of water because a man has a large tap and large service; when a leak occurs, you are as a likely to get it on a large service as on a small service, except that on a large service the pressure does not drop quite so much. That is the only factor, the delay in knowing of the leak on a service if it is a large one, the loss of head is mainly in the service. Your entry head is your source of loss in the tap, and that is almost negligible.

It is quite a common practice to limit the size of the tap and to let a man put in almost any size of service he wishes. That is not very intelligent, but most of us do it, and we ought to do it more intelligently. When it comes to the meter, we are inclined to put in oversized meters. That is not necessary, because the meter may be changed readily at small expense, but you cannot change the tap or the service without digging up the street and causing annoyance to the people who use that street and running into a large expense, either to the owner of the property or to the water company or the municipality or whoever may bear the expense. The amount of water which gets by through under-registration or lack of registration in the meters is large, just how large depends upon the character of use and size of the meter. I think that you will find that generally our meters are larger than is necessary, and we ought to reduce the size of the meter so that we will record more accurately the amount of water delivered and get a more adequate return for the water actually used in the building.

Chairman Fuller: We have some other members of this Committee who perhaps have personal experiences to state. I am going to call on Mr. Bohmann of Milwaukee.

Henry P. Bohmann: The tentative report made by this Committee shows conclusively that there is no short-cut method for controlling water waste, but that it needs an intensive campaign day in and day out. Even in a completely metered city, one cannot sit down and wait for results; if you do, your waste of water will surely increase. It would be very desirable if comparisons could be made with cities that are all metered, but here the difficulty arises as to what methods are used in presenting these figures. Some cities estimate their slippage of pumps at 15 per cent; others at 5 per cent. Then there is the great difficulty of arriving at the

amount of unmetered water. There are certain services which it is not practicable to meter, and these usually are the hardest to control. All large cities have services that are extended to the curb only, where also the house drain is extended and where many times leaks exist at the curb cock and water gets away in the drain pipe and does not show on the surface. The larger the city, the bigger the problem, because there are thousands of services extended for future use.

In Milwaukee we found it necessary to take out of the hands of the plumber the furnishing of the curb cock on account of the poor article furnished, which was the cause of a great deal of leakage. In the absence of all services being metered, I think about as accurate a method of arriving at whether the department is going forward or backward is to divide the pumpage into the total revenue received for water and arrive at your revenue per million gallons pumped. This method can be used by a city whether it is all metered or not. In the City of Milwaukee we started a campaign for the elimination of waste some ten years ago. At that time the revenue was \$45.80 per million gallons pumped. This campaign was conducted for ten years along the same lines by men connected with the department at very little expense, and we were able to increase the revenue to \$50.50, although there was no increase in water rates during the entire period.

In trying to control water waste, it is necessary to begin at the pumping station and first to ascertain whether the amount delivered into the distribution system is accurate or whether there is too large a slippage of pumps. Next, in cities where you have reservoirs there are leaks the amount of which it is very difficult to estimate. In the City of Milwaukee we have many large coal yards where they have fires in the coal piles, and in order to save the expense of calling the fire department, we give them a hydrant wrench and they are to report the amount of water used, based on the length of time the hydrant has been open. Naturally, we must assume that they report the correct amount. Then there is the use of water from fire hydrants by contractors which is very difficult to control. In some small cities I understand they are metered. In Milwaukee we frequently have 50 to 60 contractors engaged in street work of different kinds such as sidewalk construction, curbing, sewer work, street construction, etc., which makes it practically impossible to meter this kind of service. There is the paving and

repairing work done by the street car company between its tracks, which is done all over the city. We cannot expect the company to trouble water consumes all along the line to get the use of water, the company naturally uses the fire hydrant and we take its report as correct. The city itself uses water and this is almost as difficult to control as some of the contractors, because the other departments do not appreciate that it is necessary to get this information. If you wish to show the amount of water you are to account for, and each department is obliged to pay for its water, some will endeavor to keep it down to the minimum and report less than is actually used. You see the amount of water that is unmetered is more difficult to estimate than the metered water, and the difficulty of getting on a comparable basis with other cities unless they are either all metered or it is on the basis of the revenue per million gallons pumped.

I think Mr. Brush said that large cities, and for that matter small ones, ought to ascertain the night and the day consumption and use that as a basis, ascertain whether the consumption at night is too large and whether it is due to leakage in the distribution system and services, or whether there is a legitimate use during the night. I know that in Milwaukee there are many large industries that work day and night, and, therefore, it would be necessary to check up their day consumption against the consumption during the night period, in order to arrive at whether it is waste or legitimate use.

Chairman Fuller: We shall be glad to hear from any other members of the Committee who joined in this report.

Edward S. Cole: I want to bring out one important point. We cannot overemphasize the desirability of deducting the metered industrial use when we try to compare the per capita consumption of different cities. Many cities have the large metered accounts in separate books, and it should be possible to total these books as representing the trade use and to deduct it from the total consumption. This is not ideal, but it is a long step in the right direction. What is left is, of course, domestic, commercial and unaccounted for, but if we may conveniently total the metered manufacturing water and take that out, we shall approximate the ideal of segregating all but domestic use. I think it would be helpful if some of the executives and superintendents who are here would tell us what,

in their opinion, would be the cost of getting the data for the Committee for general use. If you would state how much you think it would cost to total the large meter accounts of your city, the information would be interesting and valuable.

Charles S. Foreman: As the Committee Chairman has stated, it is quite some job to obtain the necessary data and properly to analyze the same, to determine whether a water system has very much waste of water.

Along the lines Mr. Cole has just mentioned, we are endeavoring, in Kansas City, to classify all water accounts by going through all the ledgers and placing a classification letter on each account, indicative of the character of service. That is, whether commercial, manufacturing, residential, etc. At each meter reading period, after the amount of money is run on the adding machine, the amount of water consumed by each service will be run on the same machine. To do this it has been necessary to have a special twenty-nine column adding maching constructed.

After all of the accounts have been classified, the letter indicative of its class will also be run on the adding machine, with the amount of water consumed. This report, giving the total consumption of each class, and the total amount of water accounted for by meter, is sent to the Engineering Division.

It cost approximately $2600 to classify the accounts. Not very much benefit may be derived from such a system at first, because of no previous records for comparison, but as the data accumulate they will increase in value.

All water works superintendents should be considerably interested in standardizing the methods used for determining the size of taps and services. It is rather difficult in most cities to have any definite rule laid down, because of the variation in water pressure, as is the case in Kansas City, where the pressure varies from 150 pounds to as low as 30 pounds, depending upon the elevation.

We have a great many complaints from consumers bcause of low pressure and when an inspection is made to determine the cause, we usually find that the consumer's service is far too small to supply the amount of water required. In Kansas City, we have no rules regarding the size of service to be permitted, except that it shall not be less than three-quarter inch. That is, we allow the plumber to make application for any size of service that he may desire, without

regard to the character of the consumer's premises and without regard to the amount of water to be used.

There are many different methods of determining the size of tap and service, such as the floor area method or the number of openings. However, these methods will not apply to each individual city because of the varying conditions in pressure and service.

I think that, if the Committee might get the ideas and experiences of all of the water works superintendents, it would help considerably in formulating standard methods for the determination of the size of services and taps.

Dow R. Gwinn: In Terre Haute we carry about 45 pounds pressure in the residence district for houses up to eight rooms. We give them a five-eighths tap and a five-eighths lead service up to the curb, furnished by the company free of charge. Ordinarily the plumber carries a three-quarter inch line from the curb into the house. We find that arrangement gives very satisfactory service.

In regard to the production of waste, when we were 10 per cent metered, we were pumping about 1550 gallons per consumer; now that we are 98 per cent metered, we are pumping 550 gallons per consumer. In order to keep a record of the demand at night, we take a record of the output between the hours of 2 and 4 o'clock, when most of the people have stopped using water, except the railroads and large manufacturing concerns. In our engine room we have a graph which the engineer keeps up each day showing the revolutions per minute of the pumps for that period in the night. When the engineer sees that curve go up he realizes that something may be wrong with the pump, maybe a leaky valve. It suggests that he get busy and examine the pump before his attention is called to it from the office.

Caleb Mills Saville: What Mr. Brush said is quite interesting, and fits what has been the popular thought about the loss of water through under-registration of meters. That question has become quite important and we have been considerably troubled by it as related to demands for larger meters. Houses that were formerly adequately supplied by tank closets got along very nicely with a five eighths meter and a three-quarter inch service pipe. After many complaints we found, after a good deal of investigation,

that the maximum rate usual for that house was about $1\frac{1}{2}$ cubic feet per minute, and that would be only for five minutes or so, happening perhaps several times during the day. The ordinary consumption would be much less than this, would be quite low, and it would very nearly be what our standard is on the low flow of that meter.

With the advent of flushometer closets, however, came a new demand, and it was found that those same houses which formerly used $1\frac{1}{2}$ cubic feet per minute were now demanding a maximum of from $3\frac{1}{2}$ to 4 cubic feet per minute. With this came the demand for larger meters. "Please put on larger meters. The plumber says that this is the trouble in my house; the plumbing fixtures and the plumbing are all right, everything is right in the house, but the meter is too small. Now he knows." Perhaps he does. In some cases we put on the larger meter, but the call has become pretty loud and it seemed desirable to investigate. Of course, we all know that a larger meter, a three-quarter or one-inch meter costs more money than a $\frac{5}{8}$-inch meter. That is one argument against the change, but I had supposed and I used as an argument that there would be a great deal more unrecorded water passing through an inch meter than through a $\frac{5}{8}$-inch meter. It seemed logical to contend that as you could not expect meters to be built like watches and have them function perfectly, the larger the meter the less would be the registration on the low flows. Within the last month we have connected up at our yard four of the standard makes of meters. The Hersey, the Trident, the Lambert and the Worthington, five-eighths, three-quarter and one inch size of each, twelve meters in all, discharging into a tank where the water could be carefully measured. I will not give you the details of these tests, but I will say that we started with a flow of 0.02 of a cubic foot per minute, which seemed to be about what might be expected from a leak in a toilet, and continued this flow for about twelve hours. Some of the meters registered better than others on that flow, but they all registered something. I think three of them registered within 92 or 93 per cent. The next run was at a rate of 0.12 of a cubic foot per minute. Everyone of these meters ran well within the limits of the meter specifications. At a rate of 0.08 of a cubic foot per minute they all did as well. The thought came that, perhaps with intermittent flow such as one would get during the day, we might get some differences, so a man was as-

signed to work them all day. He started at 0.02 cubic foot per minute, then changed over and ran 4 cubic feet per minute, for a minute or two, then dropped to $1\frac{1}{2}$ cubic feet per minute, then down to 0.08 cubic foot per minute, for an hour or so, and so on. When the test was completed we found that even under these conditions they all measured satisfactorily. So far as could be seen from that test, there was no appreciable difference in the registration of amounts of water passed through any of those meters. You will recall that they were $\frac{5}{8}$, $\frac{3}{4}$ inch and 1 inch sizes of each standard make. This test clearly indicated that larger meters were just as sensitive as small ones in registering low water flow.

John N. Chester: I am fast becoming an advocate of a very liberal service. As Mr. Brush says, you can change the size of the meter, but it is difficult to change the size of the service. As many years as I have lived, and it is approaching sixty, until I built my own house last year I never lived in a house that I did not consider underplumbed. When you are trying to take a shower-bath and somebody else draws water you either get a cold douche or are scalded. At a plant in which I am interested, we have a high place in the city and when the sprinkling hour arrived it became necessary to shut off the standpipes and turn on direct pressure. The superintendent was constantly howling for reinforcement for that district. He bought a lot and built his house out there and I suggested to him that he plumb his house liberally, at least that he bring a liberal line in from the street. Acting on that suggestion he put in a one inch line and a one inch meter, and he made the confession when I was last out there that he had never found a shortage of water in his house, that he had plenty of pressure and plenty of volume.

I have made it a rule, in the three plants we operate, that they shall use nothing less than a three-quarter inch corporation and three-quarter inch line clear into any house. I have removed altogether the restrictions as regards what size the service shall be, protected as we are in every case by a graduated minimum or a graduated service charge. There is the schedule, we say to the consumer, take your choice and you will pay for what you take in the way of a minimum or service charge. We will reserve the right to fix the size of his meter commensurate with what his maximum demand may be. While I appreciate Mr. Brush's problem and others in

large cities where they have large office space, in Jefferson City a seven-story building is the tallest thing we have had to tackle. We have had nothing more than the ordinary industrial and commercial work, and it is not hard to fix the meter size for them, but the meter size in residences is fixed much more by the plumbing than the square foot of area or the number of people in the house. It is more likely to be the number of bath rooms and the maximum demand that can be made upon the service, than any other one feature. Now the last thing is the flushometer closet. That came to my attention about ten years ago, and I have made the same recommendation always, a graduated minimum and a graduated service charge, and let them have what they want and use it as fast as they can. Of course, I had one client who said, "We have only a four inch main on that street and about four houses connected flushometer closets in a block and our service is gone." I said, better connect up the other end of your four inch and feed it both ways, but do not admit to your customer that he cannot have water as fast as he wants to pay for it.

John Chambers: At the present time the Louisville Water Company is having made by the Pitometer Company of New York a pitometer survey of the entire city. The engineers of the Pitometer Company have been working for five or six months and have covered possibly one-third of the city. The engineer in charge of the work reports that he has never found in any city where he has made a survey a superior underground condition to that in Louisville. But one joint leak has been discovered, wasting 370,000 gallons daily. There has been found, however, a disgraceful condition of house waste. There are about fifty-three thousand services and possibly six thousand of these are metered. It is not at the present time the policy of the Louisville Water Company to meter small services, the water being paid for on an assessment basis. All large services of course are metered. I personally do not agree with the Board of Water Works in the matter of metering, but hope that there will be a change of policy at some time in the not too distant future.

Some examples of extraordinary waste will be interesting. The public schools and charitable institutions obtaining free water are the greatest wasters. The Boys High School wastes one hundred and fourteen thousand gallons per day. This is not consumption,

but actual waste. Another school wastes one hundred and four thousand gallons per day, and still another wastes seventy-eight thousand gallons. At this time all of the schools have not been examined, but there is reason to believe that conditions will be found bad in all of them. In order to reduce the high waste, two inspectors are working under the pitometer engineer making house to house inspections and serving forty-eight hour notices threatening either to install a meter at the cost of the consumer or to shut the water off. The threat to install a meter is not seriously meant, and if the repairs are not made within forty-eight hours the water is shut off according to the notice served. This system has brought remarkably favorable results and it is probable that in seventy-five or eighty per cent of the cases the repairs are made within the allowed time. It is proposed to increase the number of inspectors in order to cover the entire city before the pitometer survey is completed.

WILLIAM W. BRUSH: The question has been asked as to whether we have found anything better than the aquaphone in locating leaks. We have not found anything better than the aquaphone. We have used a form of stethoscope, but have found it unsuited to New York City conditions, due to the noise in the city streets.

As a Committee, we desire from the members of the Association:

1. The night consumption between 1 and 4 a.m.
2. The percentage of the night consumption due to large commercial users.
3. The consumption for the twenty-four hours.
4. The experience with leak prevention work.
5. Rule followed in determining the size of tap to be allowed.
6. Rule for determining the size of service to be allowed.
7. Rule for determining the size of meter to be installed.

There is one paragraph in the report that I should like to read to you as long as we have time; it is in reference to the varying cost to the community for water that is wasted;

An illustration of the varying cost to the community of the water which is wasted is afforded by New York. When the Catskill system was first utilized in 1917 and about 375 mgd. made available, the Brooklyn and Richmond systems were placed in reserve and the draft from the Croton system was cut in half. The cost of any additional water delivered by gravity from the

Croton system was about $0.25 per million gallons, as this cost was limited to the chlorine required to treat the water, the system of collecting works, aqueducts and distribution mains being adequate to deliver the additional quantity to provide for the waste of water, and no additional force being needed to operate the system.

I find that a good many get an erroneous idea of a statement of this character, and yet I do not see just why that should be so. The water cost at that particular time, the additional amount of money that you have to spend in order to provide that water, has absolutely no bearing upon what that water costs, based upon the cost of constructing the works, and it has virtually no relation to the amount that it will cost you perhaps four or five years from now for additional supply. When a million gallons of water costs you 25 cents, you cannot show any economy in stopping the waste of that water. In New York we estimate that we can stop waste at the present time by our special gangs at about $3.00 a million gallons, but it does not pay us to go into the area supplied by Croton gravity and pay $3.00 a million gallons to stop waste, if that waste at that particular time is causing no damage. It does not mean that at some future day we may not have to stop such waste, but at the present time if a million gallons cost 25 cents and it costs us over $3.00 a million gallons to stop that waste, we should not spend our time and the city's money in stopping that waste at this particular time.

If the Croton water had to be pumped, as would be the case where waste occurs on the higher ground, then the cost of the water has been about $10 per million gallons. If Brooklyn water had to be drawn on to make good the waste the cost increased to about $25 per million gallons, and when the Richmond supply was needed for this purpose the cost was about $40 per million gallons. When New York reaches the time when the construction of the works for an additional supply beyond that from the Catskill system must be started, and that time is close at hand, then each year that the starting of such construction is safely postponed, due to stopping waste, would mean a saving of over $10,000,000 per year, which would make the value of the water then saved over $500 per million gallons. Care must be exercised in the use of any figure like the one last given, as the delays in carrying through any enormous water supply project like that needed to serve New York for another twenty years growth are such as to necessitate the time allowed

being determined with several years leeway, if provision for the future is to be safely made. In other words, you cannot attempt to draw the line in developing supplies that take you a dozen or fifteen years and say "This is the time we ought to start construction," when you consider the various difficulties that may be in the way, both in starting the construction and carrying it through to successful completion. But there is a period when you are adding to your source of supply, when water saved represents a very high value per million gallons, and in a system like New York or other large cities, where you have to add your additional supply in large units, there is a time when the cost to the municipality of the water being wasted, that might be saved by water waste work, is very small. As we view it, the intelligent method to be followed in stopping waste under such conditions is to go after the waste that, when stopped, costs us less to stop than it does to allow the waste to continue.

David McLean Hanna: Mr. Brush asked a question with respect to the use of the electric leak locater. I have had a short experience with the use of the electric leak locater and find it is very useful where there is known to be a leak. By following up the service to the main, you can get directly over where the water is leaking, without breaks in the pavement of any kind, and therefore it reduces your cost of repairs by your being able to make your excavation immediately over where the water is leaking. You can dig right down to the leak and make the repairs at a minimum cost. It is necessary to do the work, of course, during the night period. The instrument is so sensitive that if there is any interfering noise you cannot get the result; everything has to be perfectly quiet; you cannot use it while there is rain falling. We started out one evening to make a test, and just as we got the instrument set, it started to rain and we had to close up shop and come back the next night to locate it. I believe it would be adaptable to following up mains to find leaks where you think there are such, by traversing along over the top of the main during the quiet hours.

DISCUSSION OF REPORTS ON PUMPING STATION BETTERMENTS[1]

Leonard A. Day: Some of these questions will be replied to by letter from some of the men who are qualified to talk along these matters. Our Committee thought that possibly this evening we might bring out discussion on some of these subjects. Our articles on condenser performance and removing oil from boiler feed water have been published, and I presume it will be of no benefit to read them again tonight. I should like to have some discussion on the subject.

Chairman Fuller: Is it not a fact that your Committee is following the policy of trying to take practices as revealed by recent installations and put into the Journal a summary of what those particular arrangements may be? And the particular topics on which later arrangements might be desired are what you want to get the views of the membership on?

Leonard A. Day: In our department we have recently experimented with powdered fuel on a small scale. A company in St. Louis loaned us a pulverizer and we built our furnace and worked up the details of the apparatus considerably. Our experience with pulverized fuel is not very gratifying. I think, however, that our experience would not be conclusive as against the better practice of pumping stations in general, because we were limited by conditions in so far as the design of the furnace was concerned. We were handicapped in not being able to dry our coal, which we found to be an absolute necessity. Our coal in St. Louis runs as high in some cases as 15 per cent moisture, and if you attempt to pulverize coal with that moisture content, you simply cannot do it. Your pulverizer chokes up and your energy for pulverizing the coal runs up about 100 per cent above normal, so that we found we would have to dry our coal if we were going to pulverize it. We also found that where we

[1] Journal, September, 1922, page 696; January, 1923, page 145; September, 1923, pages 882 and 883.

built one furnace and did not provide any means of cooling the walls, we burnt the furnace down in about two or three days, just simply melted it down. On the next one we put in hollow walls, designed a system of hollow walls and took the air for combustion through these hollow walls. That seemed to solve the problem. In modern plants, however, that is carried on to a further extent than we did. At the Lakeside Plant in Milwaukee, the air for combustion is taken from the entire boiler setting. They also have what they call water screens in the bottom of their combustion chamber, by which they had practically eliminated slag, and slag is one of the biggest bugbears in pulverized coal. We found that a furnace volume of around 5½ cubic feet per boiler horse power was necessary.

John N. Chester: I should like to ask Mr. Day if it is not his conclusion that the use of powdered fuel, like the use of stokers, does not become practical until you get a plant of a certain horse power, say 1000 h. p., and over, that it would require that big a battery in order to return the fixed charge and the upkeep out of the savings and to make it otherwise practical to be employed?

Leonard A. Day: There seem to be two types of pulverized fuel apparatus, one type which is applied in the larger central power stations in this country and which undoubtedly is not suitable for the ordinary boiler plant, until we reach a boiler horse power of approximately 5000. From there on up the power plant designers claim they can just about break even with the stoker fired plants. I talked to Mr. Mayo yesterday at the Ford Plant. They have, of course, a wonderful system of pulverized fuel there. He said that pulverized fuel installation was just about equal to that of a good stoker installation; that is, when you consider the cost, you get more economy. I think that is true in most all the modern pulverized fuel plants, but you have to pay for it in the way of initial investment. Mr. Mayo's thought there was that there was nothing in the furnace, no moving parts whatsoever in the furnace, but he has plenty of moving parts previous to the furnace. However, it is a wonderful plant, a wonderful installation of pulverized fuel. They burn three kinds of fuel, coal, by-product gas, and coke-oven gas and tar; and sometimes they burn all three fuels at the same time.

John N. Chester: How about the necessity of a more intelligent man in charge of the plant during the operation? Do you have to have them with stokers or hand-fired furnaces?

Leonard A. Day: I am inclined to think you probably do not need as intelligent a man. For firing a stoker, he must be a pretty intelligent fellow in order to get the best out of it, but you approach a condition of burning gas in a pulverized fuel which is easily set. They were running as high as 19 per cent CO_2 at the Ford Plant yesterday. Of course in ordinary stoker practice, if you average 9 or 10 per cent, you think you are doing pretty good, and the party we spoke to in the plant was surely lacking in ordinary boiler intelligence. We asked him what his flue temperature was and he said 1200 degrees. He was kind of groping around in the dark, he did not know. There has to be a master mind in a plant of that size, but for ordinary small plants, where you might decide to put in a unit type of pulverizer, I think the ordinary boiler room attendant can get along with it all right.

Chairman Fuller: Your second proposition, Mr. Day, was the driving of a low head pump by water wheel with water lead from a force main into which water was delivered by highly efficient pumping units.

John N. Chester: I had some tests made at Jefferson City some time ago to decide whether or not we were warranted in continuing driving our coagulant mixing apparatus by means of a water motor or had better abandon it and take electric current and buy our current at three cents. I think we can save at least 50 per cent of the cost of the energy by so doing.

Chairman Fuller: The next one, Mr. Day, was the question of the boiler baffling, vertical or horizontal baffling.

Leonard A. Day: I might say that as far as our practice goes, we have pretty well concluded that the vertical baffled boiler offers greater advantages than the horizontal baffled. We all know now that combustion engineers are making some wonderful strides in the design of furnaces to keep down as much as possible the cost of furnace repairs and to bring up the efficiency of the boiler and furnace.

The vertical baffle offers a decided advantage in that; if you put in one of the baffles commonly known as the Turner type of baffle, you immediately expose practically half of your tube surface to the radiant heat of the boiler and furnace. That has a tendency to keep your brick work cost down and to keep your furnace temperature a little lower. The radiant heat is quite beneficial in so far as economy of the entire unit is concerned. I think the horizontal baffle boiler was popular in the olden days because it was rather an easy baffle to handle, but unless you use the third baffle in a horizontal baffle boiler, which is more or less complicated and especially in old plants cannot be done very well, the vertical baffle seems to be much better.

W. S. Cramer: I should like to ask Mr. Day if the test on a small plant would be acceptable, if you could get anything from them? We have two seniors in the Kentucky State University who have a thesis on boiler plants this year. We have a Stirling Boiler of 265 h.p. that has a hand fired stoker, and a 250 h.p. fire tube horizontal boiler. One has a shaker grate and one has a plain grate. In making those comparisons we were advised to put in a stoker. This is a plant that is carrying a load of a million and a half gallons as a minimum, and during that time if we are operating a Stirling Boiler, we have to hand-fire it, we cannot even hand stoke it. If I had to go over it again in this plant, I do not think I should put in the hand stoker. I think the best thing is a good shaker grate. I shall be glad to give you those facts if they will be of any use to you.

Leonard A. Day: I appreciate that, Mr. Cramer. One is a hand stoker and one is a hand fired grate.

The next proposition dealt with was steam pressure and superheat. We attempted to bring this question out because everybody else is doing the same thing and there does not seem to be any limit to steam pressure and super heat now, according to the rumors that are floating around in reference to the power plants being designed. It is only natural that water works practice follows along somewhat the same lines as power station practice, in so far as economies go. What we are anxious to know is, when does it cease to pay? What steam pressures are the most economical steam pressures, and how much super heat? The central power station practice now in a good many cases is going up as high as 700 degrees total temperature. I have

been advised that the ordinary waterworks type of turbine is not adapted or rather will not show any appreciable gain in economy when steam pressure is greater than 250 pounds and 200 degrees super heat is carried. That is a subject that we might have discussed by some of the turbine men here if they care to.

Another thing is the temperature of the steam cylinders. If you are using reciprocating engines, the pumping engine people are inclined to draw an arbitrary line at 550 degrees total temperature. That might be a steam pressure of 200 pounds and 200 degrees super heat, somewhere in there. I understand recently, in fact I saw an engine being built in one of the leading shops not long ago, that was going to carry a total temperature of 630 degrees. So it looks to me, in order to be fair to the reciprocating type of unit, that you could not arbitrarily say that that unit was only good for 550 degrees total temperature and the other types of units were good for 600 degrees, without at least an investigation.

John N. Chester: I think we are most of us bound up by what we have.

Chairman Fuller: Now and then they build new stations, you know.

John N. Chester: The question Mr. Day raises is one for the new stations. Naturally there is a difference between the temperature you can carry in the reciprocating engine and one that will be consistent in the turbine, for in the reciprocating engine we have got the valves and overheating of the oil and a good many things like that, all of which we must consider. Like powdered fuel, however, it introduces other complications that sometimes, before we get through, eat up economies that we have created by increasing our temperature and the pressure of our steam. I do not believe the limit of pressure and temperature has been reached in turbine practice, and that is borne out by the fact that pretty nearly every big central electric station built over-steps everything else before it. But when we come to talk about 500 and 1600 h.p. units of boilers and stokers, it is very different from what Mr. Cramer has down in Lexington where he has put a stoker under a 250 h.p. boiler and where I would not expect him to reach any other conclusion than the one he has drawn. I bumped my head the same way; I found that out by experience.

Chairman Fuller: Mr. Day and Mr. Chester, is it not a fact that these are the propositions on which your Committee welcome suggestions, and if anyone has any special interest in them, you want to bring out the latest advanced information for the benefit of the members of this Association? I do not believe we are going to gain a great deal by trying to discuss these things academically here tonight, but I do want to express my appreciation of and full sympathy with the idea that we have got a real live committee on pumping station betterments. Anybody that has any idea that they want to bring up at a later meeting or at any time to be put into the report of this Committee should communicate now with Mr. Day.

REPORT OF COMMITTEE NO. 10 ON STANDARDIZATION OF SERVICES

Your Committee on Standardization of Services found the subject rather more complicated than they expected. The chemist of the Committee was asked the seemingly simple question, "What degree of hardness is necessary to make it safe to use lead pipe." This question brought up many complications and other chemists have been added to the Committee to make a more exhaustive study of this subject.

Your Committee decided to divide the proposition into two heads, the mechanical, dealing with various materials for services and the chemical. The latter will take up especially the use of lead pipe from the health point of view.

In the mechanical field many new elements have entered, the centrifugally cast pipe in small sizes, small sized cast iron pipe with prepared joints, cement lined pipe, etc. These are all questions that we cannot report on before sending out a questionnaire and getting data from the users of various kinds of service pipes. We want information concerning the cost of services and their lasting qualities and we can get this only from the users of the various materials.

It is not the intention to deal with the sizes of services for various service, but we do propose, if possible, to get some information concerning the demands made by the introduction of the flushometer water closet and the demand it creates for larger service pipes.

We will endeavor to get some information on the strength of lead pipe. We now buy lead pipe by classes, A, AA, AAA, etc., getting about the same thickness of shell for all sizes, the same for a $\frac{5}{8}$- as for a 2-inch. Either we are buying too much lead when we buy $\frac{5}{8}$-inch or too little when we buy 2-inch, unless we adopt a system of using a different class for each size. The attempt will be to classify lead pipe much the same as cast iron is now classified.

Your Committee understands that it is expected to find out and report on what is the best material for services from all standpoints, health, durability, cost, etc., and if the questionnaire may be sent

and receive proper attention, exact replies and data, the information thus obtained may be tabulated and embodied in a report.

B. J. Bleistein,
G. C. Bunker,
R. E. Greenfield,
C. D. Howard,
R. B. Morse,
George Read,
M. C. Whipple,
S. DeM. Gage,
J. M. Diven,
Chairman.

DISCUSSION

Chairman Fuller: Gentlemen, this question of lead poisoning is something that is attracting a great deal of attention in England, as I found this past winter. A rather sad feature is that some of the water works people in England have actually died from lead poisoning. We have made quite an effort during the last few months to get hold of someone who has the courage, time and patience to look through those English reports and find out what the controlling points are in respect to the solubility of lead by waters of different types. I know when I left Massachusetts some thirty years ago and went to Louisville, Kentucky, to live, I found right away that lead pipe when it was brand new was dissolved by the Ohio River water, but after a little while it got a coating of basic carbonate, which was impervious. That shows the difference between soft waters in New England and the water of the Ohio River; but where the dividing line is between a water which gives trouble to the point of corrosion and even to the point of bringing about lead poisoning which is cumulative, and those which form quite readily this basic carbonate, I do not know. To stop lead poisoning, in some instances they are adding precipitated chalk, what I would call carbonate of lime, and making it a regular feature of the treatment of the water supply, in order to bring about an increase of hardness.

This Committee is one that, as Mr. Diven has said, is clearly at a stage where they have two divisions, a mechanical and a chemical division. On the mechanical side, they want to go ahead with a questionnaire. I am fully in sympathy with it, and also with their desire to get practical information on the chemical end. It

is going to take a lot of time, but it is a well worth while proposition. Waters highly charged with free carbonic acid as from the Memphis wells, means that one of our tasks is treatment to keep carbonic acid down low so as to make that water literally kind and gentle. I think Mr. Diven has said enough to indicate that you have an interesting set of topics in the hands of this Committee.

Charles B. Burdick: I should like to ask what is the character of those waters in England that are causing that lead poisoning trouble, and why is it that that trouble is only coming to a head at the present time, at this late day.

Chairman Fuller: I think there are three characteristics. There is high free carbonic acid, in the first instance. In the second instance there is a group of what I might call organic acids, humic acids. Decayed leaves and decayed vegetation generally will produce substances which have an acid reaction; they tend to add their mite. The third element is that there is insufficient bicarbonate or normal carbonate which will produce this coating of lead oxide and lead carbonate which forms this natural protective coating. In other words, you have the two corrosive elements in this water, and the absence of enough hardness to bring about the coating which stops the corrosion.

It was investigated by the Local Government Board of England, corresponding, perhaps, to our United States Public Health Service, over twenty years ago. It is not a novelty, but they have been more watchful lately. I think Alexander Houston was in charge of this work for the Local Government Board (now the Ministry of Health) that has supervisory powers on water expenditures, so that no municipality can issue bonds for water works improvements unless the project meets the approval of this central agency. Those English reports are available in print. It is a time-consuming job to brief them, but it is well worth while. These Committees under the Standardization Council are doing good work. It is gratifying to the Standardization Council to have you discuss these reports and ask questions. If questions occur to you after you get home, write to the chairmen of those Committees. Let us keep going and bring out a set of committee reports that will make the beginnings of a manual that it is the ambition of the Standardization Council to produce to set forth standard water works practice in America.

Rudolph Hering

Died May 30, 1923

Rudolph Hering, born at Philadelphia, Pa., February 26, 1847, was a son of Dr. Constantine Hering, a prominent physician and one of the leaders among German-trained medical men who founded Homeopathy in this country. In 1860 he was sent to Dresden where he attended the public high school and later the Royal Saxon Polytechnic Institute, from which he graduated in 1867 as Civil Engineer. Returning to the United States, he found work at Prospect Park, Brooklyn, and later assisted in the laying out of Fairmount Park, Philadelphia.

Numerous cities in this country suffered at intervals from severe epidemics of yellow fever. With few exceptions, sewerage arrangements in this country at that time were both meager and faulty and far below European practice. Mr. Hering was commissioned by the National Board of Health to make a thorough investigation of European sewerage practice. This engaged his attention on the ground in large representative cities of the principal European countries and led to the preparation in 1881 of what is doubtless the most important report ever appearing in this country as to the fundamental principles and arrangements of structures for the satisfactory removal of household wastes by water carriage.

Following his return from abroad, he began his consulting practice, although from 1882 to 1888 his time was very largely devoted to three important engagements. The first was the supervision in the field of an exhaustive study of new sources of water supply for the City of Philadelphia. In the second, from 1885 to 1887, he served as Chief Engineer of the Chicago Drainage and Water Supply Commission, which was created to recommend a method of keeping the sewage of the city out of Lake Michigan. These investigations were an important step in the creation of the Chicago Drainage Canal. His third large investigation was in New York City where he reported to General Newton as to betterments to the basic design used for the

local system of collecting sewers and also on arrangements of the outfall sewers, which on his advice were gradually extended from bulkhead to pierhead lines in the City of New York.

Although the structural aspects of engineering had been of principal interest to him perhaps during the first ten years of his active work, he had the vision to see that it was important to keep abreast of the times, not only with regard to the earlier recognized phases of engineering, but also in the allied subjects of biology and chemistry.

Although Dr. Hering was one of the first to recommend mechanical filters for pumping the water supplies at Atlanta, and elsewhere, and was connected with important water supply investigations at New York, Philadelphia, Washington, New Orleans, Columbus, Montreal, Minneapolis and numerous smaller places, his accomplishments were greatest in the field of sewerage and sewage disposal and led to his having been designated years ago as the "Dean of Sanitary Engineering" in this country. Recognition of such standing was perhaps first made by President Harrison, who, in 1889, appointed him Chairman of a Commission to prepare a program for sewerage improvements for Washington, D. C.

Dr. Hering was an active worker on the committees of various professional organizations as well as civic movements. His most important work was undoubtedly that for the American Public Health Association in the matter of the collection and disposal of refuse. He gathered statistics as to results of operation and otherwise elucidated practice in this country and Europe. Some twenty-five years ago he gave liberally of his own time and money for gathering information upon this subject, although his activities in the field of water supply and sewerage did not permit him to publish the results of his investigations in the disposal of solid wastes of the municipalities.

Dr. Hering was in partnership with George W. Fuller, M. Am. Soc. C. E., from 1901 to 1911 and with John H. Gregory, M. Am. Soc. C. E., from 1911 to 1915. After the latter date his activities were confined largely to work upon a book on "Collection and Disposal of Refuse" of which he was a joint author with Samuel A. Greeley, M. Am. Soc. C. E.

His kindly interest in helping young engineers was a lovable trait which he revealed to many, both in this country and abroad, and thereby he proved to have been a strong inspiration to many a struggling young engineer. He had an unusual gift of learning what

was new in European practice and in bringing the principles back to this country and stating them in a way that their usefulness might be available to his co-workers in America. By many he was considered the foremost of American engineers in teaching his associates to be wisely guided by developments abroad.

He received an honorary degree of Doctor of Science from the University of Pennsylvania in 1907, and an honorary degree of Doctor of Engineering from the Polytechnic Institute at Dresden in 1922. He was a member of a large number of engineering societies both in this country and in Europe. He was an honorary member of the New England Water Works Association and of the American Water Works Association and a Past President of the American Public Health Association. He became a member of the American Society of Civil Engineers in 1876, was Director in 1891, 1897 to 1899, and Vice President in 1900 to 1901.

He is survived by his widow and five children.

George W. Fuller.

DISCUSSION

AN ANAEROBIC, SPORE-FORMING FERMENTER

Since the publication by Raab[1] of a report of a lactose fermenting spore-former at Minneapolis, it seems worth while to add information developed on a similar organism in the laboratory of the Indianapolis Water Company.

This report is part of a paper presented to the Indiana Section of the American Chemical Society in November, 1918, on work done between the November and June previous.

The organism is a winter visitor, being seldom or never encountered during the warm months. This applies to fermenting spore-formers in general, 89 per cent of our isolations of them occurring between November and May.

Many anaerobic spore-forming gas-formers occur in raw water and are reduced in purification. They are noted only in sterilized water on account of the relative volumes enriched, and also since they grow poorly, or not at all, on the usual separatory media.

Sterilized water has lost many of the common aerobic bacteria and it often happens that endo plates made from gas-forming enrichments produce no growth whatever. Of more than 4100 positive presumptive enrichments of sterilized water, 43 per cent gave no growth on endo and only 10 per cent confirm.

Very frequently this butyric acid-forming bacterium is present in such enrichments. For three winters attempts were made to isolate it using the usual plating methods. Though large amounts of water and enrichments were plated and hundreds of transfers made, no gas-former was ever obtained.

In the winter of 1917–1918, in connection with other work it became very desirable to know more of this organism and a determined effort was made to isolate it.

Partial sterilization showed it to be a spore-former, but always mixed with a non fermenting spore-former, which could be isolated by plating in the ordinary way but not on endo. The non-gas-former

[1] JOURNAL, November, 1923, page 1051.

was found to be non-motile. In cultures of the two where gas was formed there was always motility noted.

After some failures with the old B. typhosus filter tube, the cotton plug in the U tube was replaced with fine sand. The motile gas-former is able to travel through it leaving the non-motile organism behind. However, if most of the sand is in the uninoculated arm, gas-formation in the filter medium may carry the non-motile one up and result in a mixed culture.

In this way a pure culture was obtained, but on transfer to new media it was found to grow only in milk. The mixed culture in milk produced coagulation and then rapid peptonization. The pure culture produced coagulation but no peptonization.

It was found that the fuchsin in the endo agar prevented the growth of the non-gas-former, and that in milk the gas-former could tolerate a fuchsin concentration of 1:30000. By transferring from a heated enrichment (to eliminate non-spore-formers) to fuchsin milk, growth of the gas-former occurred with no sign of peptonization. However from 3 to 6 transfers through fuchsin milk were required to eliminate the non-gas-former whose spores were carried along to new enrichments and had to be eliminated by dilution.

We now had two organisms, one of which would grow in milk and in no other medium except with the non-gas-former present. The non-gas-former, then, must modify peptone or sugar in some way to render it available as food for the gas-former. It is not a case of oxygen consumption on the part of the non-gas-former since incubation was carried out in freshly steamed media in an atmosphere of carbon dioxide. It seems to be a case of partial commensalism.

In enrichments of the water, gas formation is slow being noted only after twenty-four hours. In transfers of the mixed culture it is very rapid, often being vigorous in less than twelve hours, on account of the volume of inoculation and the physiological condition of the two organisms. Then the effect of the non-gas-former on the media is realized early. Standard peptone medium was inoculated with the non-gas-former and incubated for six hours. It was then sterilized, filtered, dextrose added and inoculated with the gas-former. In it the gas-former grew quite well.

In this medium, simplified by the non-gas-former, plantings were made using the following fermentable substances—*lactose, dextrose, sucrose, adonite, dulcite, salicin, galactose, maltose, glycerine* and *potato starch*. Of these only *lactose, dextrose, galactose* and *maltose*

were fermented. However, in actual combination with the non-gas-former it is able to attack sucrose and starch though the organism elaborates no measurable diastatic enzyme.

There has been no growth in any medium without fermentation.

The action of the non-gas-former was further demonstrated by growing it in plain broth in a collodion tube immersed in a tube of dextrose broth inoculated with the gas-former, which in this situation grew well.

The non-gas-former was known to have a proteolytic action on caseine. It was found also to act on gelatin, fibrin and nutrose. Only 0.05 cc of a seventy-two-hour culture was required to liquify 4 cc. of gelatin in twenty-four hours and 3 cc. dissolved 0.01 cc. of nutrose in thirty minutes at 37°C.

This opened up the matter of peptones and six were obtained for test. Ammonia was determined by distillation without added alkali and reported as per cent nitrogen. Amino acids were determined by the Sorensen method and reported in terms of cc. of N/10 NaOH per gram of sample.

PEPTONE	AMMONIA	AMINO ACIDS	GAS-FORMER GROWTH
Baker		6.2	−
Difco	0.09	20	−
Witte	0.01	11	−
Armour	1.47	30	+
Fairchild	0.5	27	+
Aminoid	0.7	55	+

Armour and Fairchild peptones were found to be higher in Tyrosine than the rest, but the difference was too slight to account for the great cultural difference. Ammonium sulfate added to unfavorable media had no beneficial effect. The chemical work indicates only that the organism requires a simplified peptone.

Lactose and dextrose broth containing dibasic sodium phosphate (or sodium hydrate) when sterilized at high temperatures, 15 pounds for fifteen minutes, were satisfactory media. Sterilizing the ingredients separately or in any combination of two, except sugar and salt, and mixing before inoculation gave an unsatisfactory medium.

Several freak media were prepared by adding a small piece of the material to tubes of distilled water and sterilizing. The following supported growth with gas-formation: liver, potato, beans, corn,

carrot, turnip, alfalfa, pumpkin seed, pumpkin meat, chard, beet, celery, onion, oats, rice, parsnips, and salsify. These did not support growth: raisin, prune, plum, California grape, apple seed, orange and applemeat.

Fermentable sugars must have been present in the fruits. Perhaps high acidity or the absence of available nitrogen prevented growth.

Microscopically the organism is 3.5 to 5 μ long and 1 to 1.5 wide. Spores form at the end of the cell and are larger than the cell containing them. In motile chains this gives the appearance of a head. Spores stain easily and are Gram positive. Flagella stain fairly easily with gentian violet (carbol) in vitro, but not with von Ermengem's or Loeffler's stain. Grows only with the formation of gas. It is anaerobic but may be grown in air in freshly steamed media. Ferments lactose, dextrose, galactose and maltose with the formation of acid and gas. Butyric acid is always formed in fermentation. It grows in many vegetable infusions and not at all in meat except liver.

It is non-pathogenic for rabbits and guinea-pigs, subcutaneously, intraperitoneally or by mouth.

The organism attracts undue attention on account of the butyric acid odor of its cultures. It is certainly non-pathogenic and seems to be of no sanitary significance.

C. K. Calvert.[2]

[2] Sanitary District of Indianapolis, Ind.

SOCIETY AFFAIRS

IOWA SECTION

The ninth annual meeting of the Iowa Section was called to order on October 24, 1923 by Colonel Edward Bartow, Chairman of the Section, in the Chemistry Building, Iowa State College, Ames, Iowa, with thirty-five members and guests present.

Dean Anson Marston, of the College of Engineering of Iowa State College, officially welcomed the Section to the campus of the institution. Chairman Bartow in reply expressed the appreciation of the Iowa Section of the opportunity afforded the Section to meet at Ames.

Max Levine then read a paper written by himself and Clair S. Linton, Research Assistant, "On the Differentiation of Human and Soil Strains of the Aerogenes Section of the Colon Group of Bacteria." The paper was discussed by Jack J. Hinman, Jr., C. O. Bates, A. M. Buswell and M. Levine.

A. M. Buswell read a paper entitled "The Microbiology of Activated Sludge," which was discussed by Chairman Bartow.

Edward Bartow followed with a paper on "Seasonal Variation in a Well Water Supply." The paper was discussed by A. M. Buswell, L. I. Birdsall and E. Bartow.

Dean S. W. Beyer, Dean of Industrial Science and Head of the Department of Geology, Iowa State College, addressed the Section on "The Geology of Water Supply." His talk was discussed by H. F. Blomquist and Chairman Bartow.

The Section then proceeded to the discussion of the topics listed for Round Table Discussion, as follows:

Tastes and Odors from Algae. Discussed by C. O. Bates, Jack J. Hinman, Jr., Earle L. Waterman, Thomas Healey, Frank Lawlor, A. E. Anderson, Dale L. Maffitt, Lewis I. Birdsall, W. R. Gelston, William Luscombe, W. W. DeBerard, S. E. Buck and E. B. McGlothlen.

The Section adjourned at 5:40 p.m. for supper, at which forty members and guests were present.

The Section assembled in the evening in the large lecture room of the Hall of Engineering. Papers were read as follows:

"Operation Records for Small Water Works," by Earle L. Waterman; discussion by H. V. Pedersen, Jack J. Hinman, Jr., R. H. Holbrook and E. B. McGlothlen.

"Supervision of Water Treatment Plants in Michigan," by Edward Rich; discussion by Chairman Bartow.

"Publicity at the Water Plant," by Jack J. Hinman, Jr.; discussion by Edward Rich.

The meeting adjourned until morning, when sessions were resumed at the Chemistry Building, October 25. Vice Chairman H. F. Blomquist presided. Papers were read, as follows:

"The Ames Water Supply," by P. F. Hopkins; discussion by C. S. Nichols and William Molis.

"The Iowa State College Water Supply," by C. S. Nichols; discussion by W. M. Householder, P. F. Hopkins and Max Levine.

"The Boone Water Supply," by Mr. C. L. Ehrhart; discussion by William Molis, Thomas Maloney, Wm. Luscombe, C. S. Nichols, H. F. Blomquist, P. F. Hopkins and Harry J. Corcoran.

"Shallow Wells," by H. V. Pedersen; discussion by H. F. Blomquist, L. I. Birdsall, C. S. Nichols and Wm. Luscombe.

Chairman Bartow announced the appointment of the following committees:

Nominations Committee: Frank Lawlor, Burlington, Chairman; Charles R. Henderson, Davenport, and Earle L. Waterman, Iowa City.

Resolution Committee: Thomas B. Maloney, Council Bluffs, Chairman; C. O. Bates, Cedar Rapids, and C. D. Hays, Huron, South Dakota.

Auditing Committee: H. F. Blomquist, Cedar Rapids, Chairman; H. V. Pederson, Des Moines, and A. T. Luce, Marshalltown.

The Section adjourned for lunch. During the luncheon, Chairman Bartow brought in Mr. George W. Fuller, President of the American Water Works Association. Mr. Fuller gave a short talk on the American Water Works Association and its benefits. Forty-five members and guests attended the luncheon.

The Section re-assembled at the Chemistry Building for the following papers:

W. H. Kimball's paper on "Settling Basin Improvements at Davenport" was read by title in his absence.

A paper not on the printed program was substituted for Mr. Kimball's paper. This paper was: "The Coöperative Work of the Omaha and Council Bluffs Electrolysis Committee"[1] by F. H. Patton, Division Supervisor of Plant Methods, Northwestern Bell Telephone Company, Omaha, Nebraska, and Chairman, Omaha and Council Bluffs, Electrolysis Committee. The paper was discussed by William Luscombe.

"Financing Water Main Extensions," by H. F. Blomquist. The paper was discussed by Thomas B. Maloney, George W. Fuller, R. H. Holbrook, A. T. Luce and Wm. Molis. It was moved by Royal R. Holbrook and seconded by C. L. Ehrhart that the incoming chairman be instructed to appoint a committee to push the bill introduced at the last legislature in Iowa, concerning the installation of water mains by municipal water plants, so that all extension first costs would not have to be met out of the funds of the plant, but that the costs of installation would be borne by property owners until the mains were actually used. Carried.

Harry J. Corcoran, Chief Engineer, Iowa Insurance Service Bureau, Des Moines, then read his paper entitled: "The Relationship of Water Works to Fire Insurance Rates."[2]

George W. Fuller, addressed the Section on the subject of the condition of the water works of Europe at the present time. After Mr. Fuller had finished his remarks, they were discussed by E. Bartow, Jack J. Hinman, Jr., S. E. Buck, H. F. Blomquist and E. B. McGlothlen.

The Auditing Committee, by H. F. Blomquist, Chairman, reported that they had examined the books of the Secretary-Treasurer and had found them to be correct. The report was accepted.

The Nominating Committee, by the chairman, Frank Lawlor, brought in the following ticket:

For Chairman—Mr. H. F. Blomquist, of Cedar Rapids, Iowa.

For Vice Chairman—Dr. Max Levine, of Ames, Iowa.

For Directors—Mr. L. O. Minor, Plattsmouth, Nebraska; and Mr. Thomas Healey, Davenport, Iowa.

It was moved and seconded that the nominations be closed and that the secretary be instructed to cast a unanimous ballot for the persons nominated. Carried.

[1] See page 72 of this Journal.

[2] See page 79 of this Journal.

The Resolutions Committee, by its chairman Thomas D. Maloney, brought in the following resolutions:

1. That the Iowa Section extend its thanks and appreciation to the Iowa State College at Ames, and to President R. A. Pearson, for the use of the Hall of Chemistry as a meeting place, and for the interest, help and coöperation given by individuals toward making the Ninth Annual Meeting successful.

2. That the Iowa Section extend its thanks and appreciation to the Engineering Extension Division of the Iowa State College for the manner in which it has coöperated in the preparations for, and the conduct of, the business of the Annual Meeting.

3. That the Iowa Section extend its thanks and appreciation to the Ames Chamber of Commerce for the use of its rooms and the many courtesies extended.

4. That the Iowa Section extend its special thanks to the Faculty of Iowa State College, and in particular to Professor S. W. Beyer, of the Department of Geology, to Professor W. F. Coover, of the Department of Chemistry, Professor C. S. Nichols of the Department of Civil Engineering, and to Director D. C. Faber, Mr. Royal R. Holbrook, Mr. Rolland Wallis, and Mr. Stanley Pinel of the Engineering Extension Division, for the courtesies shown to the Section and its individual members by these gentlemen.

5. That the Iowa Section extend its special thanks to Dr. Max Levine, of Iowa State College, for his excellent paper on the differentiation of important lactose-fermenting bacteria.

6. That the Iowa Section extend its thanks and appreciation to Dr. Edward Bartow, our Chairman, and to Jack Hinman, our Secretary, and that the Section record its pleasure to know of their recognition by the American Water Works Association at the National Meeting.

7. That the Iowa Section extend its thanks to A. M. Buswell, P. H. Patton, Edward D. Rich, Harry J. Corcoran, Earle L. Waterman, Hans V. Pedersen, H. F. Blomquist, P. F. Hopkins and C. L. Ehrhart for the excellent papers which these gentlemen read before the Section.

8. That the Iowa Section endorses heartily the proposition of Edward W. Bok in offering one hundred thousand dollars ($100,000) to any American who will devise a practical means by which war may be prevented between nations.

9. That the Iowa Section express its regret at the untimely death of Robert B. Wallace of Council Bluffs, and that the sympathy of the Section be sent to his bereaved family.

10. That the Iowa Section extend its most hearty welcome to each of its new members, and express its hope that each member of the Section nowin good standing will endeavor to bring into the Association and the Section at least one new member during the coming year, so that the Tenth Annual Meeting may be even more enjoyable and beneficial through their attendance and participation.

11. That a copy of these resolutions be spread upon the minutes of the meeting and that copies of the pertinent sections be sent to the President of the Iowa State College and to other persons concerned.

12. That the Iowa Section express to President George W. Fuller its pleasure at having him present at the meeting and in having the opportunity to listen to his addresses.

13. That the Iowa Section extend its thanks to the Boone Chamber of Commerce for providing transportation from Ames to Boone and for other courtesies extended.

14. That the Iowa Section thank the City of Boone, and particularly the Mayor, and C. L. Ehrhart, the Superintendent of Water Works, for the opportunity to see the two plants belonging to the city and for the courteous treatment received.

It was moved that the report of the committee be accepted. This was carried unanimously.

C. L. Ehrhart moved that the incoming chairman be instructed to appoint at the earliest convenient time a committee to make a study of operation records for small water works and to endeavor to bring about the adoption of such records in the small plants of the state. The motion was seconded and carried.

This having concluded the business session, the Section proceeded to take up once more the Round Table Discussions:

Iron in Water Supplies. Discussed by C. S. Nichols and E. B. McGlothlen.

Water Waste Surveys. Discussed by Harry J. Corcoran, A. E. Skinner, S. E. Buck, William Molis and Thomas Healey.

Are Bookkeeping Machines Adapted to Small Water Works Billing? Discussed by H. F. Blomquist, A. T. Luce and C. J. Delacey.

Who Should Maintain Curb Shutoffs? Discussed by Thomas Healey, S. E. Buck, F. M. Johnson, E. B. McGlothlen and R. A. Douglass.

Corrosion of Hydrant Valve Stems. Discussed by R. A. Douglass, Thomas Healey, A. T. Luce, F. M. Johnson and H. F. Blomquist.

The Use of Flush Tanks in Sewers. Discussed by E. B. McGlothlen, Thomas Healey, William Molis and T. E. Nichols.

Payment for Water by City Departments. Discussed by A. T. Luce, George W. Fuller, J. J. Murtue, E. B. McGlothlen, A. T. Luce, Frank Lawlor, Harry J. Corcoran, William Molis, H. F. Blomquist and P. H. Patton.

The Section adjourned at 5:50 p.m. and the members and guests proceeded to dinner. After dinner they assembled at the rooms of the Chamber of Commerce of the City of Ames for a special enter-

tainment which had been provided by the Chamber of Commerce and the Ames Engineering Society.

The members of the Section assembled at 9:00 a.m. the following day, October 26, at the Chemistry Building of Iowa State College and were taken in automobiles to see the water plant of the City of Ames and the independent plant belonging to the Iowa State College, which supplies the college and also sells water to the City of Ames for the supply of the fourth ward.

At 11:00 a.m. automobiles from Boone were waiting at the Central Building of Iowa State College for the members of the Section on their return from their inspection of the Ames Plants. The Section had an excellent dinner provided by the Manufacturers Agents in the Elks' Club of Boone. After the dinner a musical program and dance was provided and a few of the members of the Section made short talks.

After the River Station of the Boone Water Department was inspected, the members were taken to the City Station. The meeting was adjourned and the members of the Section departed for their homes.

The attendance at the various meetings averaged between 45 and 50.

After the meeting the newly elected officers met and re-appointed Jack J. Hinman, Jr., to the office of Secretary-Treasurer. The Tenth Annual Meeting will be held at Iowa City, Iowa, by constitutional provision.

In a letter dated November 10, 1923, Chairman-Elect H. F. Blomquist has made the following appointments to the committees authorized by the Section at the Ninth Annual Meeting:

Legislative Committee on Assessment for Water Main Extensions: Thomas B. Maloney, Chairman, C. L. Ehrhart, Chas. S. Denman, John W. Pray, Wm. Molis, J. W. McEvoy, Phil. Carlin and George W. Shoemaker.

Committee on Operation Records for Small Water Works: Royal H. Holbrook, Chairman, Earle L. Waterman and E. B. McGlothlen.

FOUR-STATE SECTION

A luncheon for the members of the Four-State Section was held at the Engineers' Club of Philadelphia, on Tuesday, October 16, 1923.

An informal meeting of the Section was held following the luncheon, after which those present, through the courtesy of the Engineers' Club of Philadelphia, were given the privilege of attending a large meeting at which the question of "Pollution of Streams" was discussed by many prominent engineers and water works men.

This was the first meeting of the Four-State Section since 1920, and a large number of the members were in attendance.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12, refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Second Annual Report, Ohio Conference on Water Purification, 1922. 1923; 152 pp. **Tastes and Odors from Industrial Wastes Containing Phenol.** Use of chlorine has been omitted at those plants where chlorine application constitutes true factor of safety (Cincinnati, Portsmouth, Ironton, Steubenville). Other plants have decreased the amount of chlorine used (Lorain, Cleveland); or omitted chlorination, substituting excess lime treatment (Marietta, Youngstown); or a combination of both (Bellaire, East Liverpool). **Load Factors.** 20° and 37° bacterial counts were equally favored as routine plant control methods. It was decided that either temperature could be employed and that State Dept. of Health would not expect reports to be made, as a routine, on both. Conference was emphatically in favor of relying on presumptive B. coli test for routine plant control, percentage removals being almost identical with those calculated from confirmed B. coli indices. Chlorination should be applied to filter effluent as a true factor of safety and present U. S. P. H. S. standard, of 2 B. coli per 100 cc. as a maximum, was reasonable, and should be attained. Bacterial load of purification processes was discussed, and an effective size of 0.35–45 mm. for filter sand for Ohio conditions was endorsed. **Analysis.** Consensus of opinion was, that determination of H-ion concentration has no practical significance in water purification plant control in Ohio region, excepting at Akron, where, with soft colored water, it is believed that use of acid alum, to adjust pH from 7.6 to optimum of 6.2, would result in more economical and satisfactory coagulation. **Report of Akron.** J. S. Gettrust. 38–56. Interesting data on operation of Akron plant: efficiencies of different steps in process, as measured by bacterial counts at 20° and 37°C., and by B. coli tests: effect of size of sand, and of bacterial burden: and experiments on pH control, are presented: together with summaries of results for 1916–22 inclusive. Tests on filters with various effective sizes of sand demonstrated marked effect of finer sand in shortening period of service. It is considered that it would be a hardship for some plants to have to meet the U. S. P. H. S. standard with filter effluent, and it is suggested that plants dealing with difficult waters be permitted to chlorinate applied water, using only sufficient coagulant to produce a clear sparkling effluent. **A Study of Percentage Removals at the Cincinnati Plant.** Clarence Bahlman. 57–65. Percentage removals at Cincinnati Plant during 1919–22 are summarized and discussed. Bacterial efficiencies (20°C.) are usually higher than B. coli removals for sedi-

mentation and coagulation; but, for filtration and disinfection, B. coli efficiencies are the higher. In sharp contrast with sedimentation and coagulation, higher bacterial removals are obtained from the filters when water applied is of low bacterial count. Low temperatures tend to reduce removal of turbidity and bacteria by coagulation; highest efficiencies by filtration are obtained from May to September when microscopic organisms are most prevalent. Multiplication lowers bacterial and B. coli removals by coagulation in warm weather, such multiplication occurring only at times of low turbidity. Chlorinated water invariably shows higher counts than filter effluent during summer; but temperature seems to have no effect on B. coli removals by chlorination. **The Relationship between Gas-formers and Confirmed B. coli at the Cincinnati Filtration Plant.** CLARENCE BAHLMAN. 66–70. Over 85 per cent of lactose-fermenters in water at Cincinnati Plant confirm to reactions of B. coli. Percentage of presumptive tests which confirm average 88–90 for all waters except chlorinated water, in which confirmations average only 84 per cent. **Relation between Bacterial Load and Quality of Effluent at the Cincinnati Filtration Plant.** CLARENCE BAHLMAN. 71–3. Cincinnati plant, for several years, has been operated to produce filter effluent which will, as near as possible, meet Treasury Dept. Standard. This policy has resulted in material improvement in quality of effluent, without unwarranted increase in operating costs. Following have been found to be maximum B. coli contents per 100 cc., consistent with production of such an effluent: raw water, 1100; settled water, 225; applied water, 50. **Discussion of Questions Involving Study of Load Factors as Applied to the Cincinnati Filtration Plant.** CLARENCE BAHLMAN. 74–7. Load factors and methods of measuring efficiencies are discussed, and data on filters at Cincinnati Plant are given. Measurement of efficiencies by 20° count is more useful than by 37° count, as there is greater difference between number of bacteria in effluent and in chlorinated water by former method. **A Study of Load Factors on the Division Ave. Filtration Plant at Cleveland, Ohio.** J. W. ELLMS AND W. C. LAWRENCE. 78–97. Laboratory results for 1921–22 are given, from which it is concluded that raw water supply is not yet sufficiently polluted to overburden a well operated filter plant. To obtain highest percentage bacterial reductions in water such as that of Great Lakes, it is necessary to use much larger amounts of chemical coagulants than are required to effect clarification; and it seems justifiable to rely, to certain extent, on disinfection. It has been observed that in most cases bacterial content (including B. coli) of disinfected filtered water is lower than that calculated from Streeter's formula. **A Discussion of the Merits of Recently Developed Tests for Small Amounts of Phenolic Compounds Sometimes Found in Public Drinking Water Supplies.** J. W. ELLMS, L. A. MARSHALL AND WENDELL PHILLIPS. 98–101. The phosphotungstic-phosphomolybdic acid and azo dye tests for phenols are not sufficiently specific for use in examination of natural water supplies. The only specific test is chlorine taste test suggested by Ellms (This J: 9: 463, 1922). There is as yet no satisfactory quantitative test. **An Investigation of the Effect of Resanding with Fine Sand Certain of the Large Filters of the Division Ave. Filtration Plant, Cleveland, Ohio.** J. W. ELLMS. 102–9. Experiments with fine filter sand, 0.30 mm. effective size, as compared with 0.49 mm. now in use, have indicated that efficiency is not materially

greater with fine sand, while period of service is reduced 50–65 per cent and percentage wash water increased 100–200 per cent. **Effect of Chlorination of Raw Water Prior to Filtration, at the Division Ave. Filtration Plant, Cleveland, Ohio.** J. W. Ellms. 110–3. Concluded from data obtained from 4-week test period of prechlorination, that such treatment is ineffective, if residual chlorine remains in water applied to filters. Free chlorine attacks colloidal coating on sand grains and destroys ability of filter to remove bacteria in applied water, or hold those contained within the bed. Subsequent application of large amounts of alum does not immediately rectify this condition. **Studies on the Effect of Hydrogen Ion Concentration Adjustments on the Coagulation, Sedimentation, and Filtration of Lake Erie Water using Sulfate of Alumina as the Coagulant.** J. W. Ellms and L. A. Marshall. 114–29. Interesting data on variations in pH of Lake Erie water, due to natural causes and to addition of coagulants, and observations on effect of such variations on operation of an experimental filter plant, are given. Experiments indicated optimum, or isolectric point, for alum treatment of lake water to be pH 7.0–7.1. Amount of alum necessary to adjust to this value is considerably in excess of that required to effect clarification, and entails expense not warranted by results obtained; hence pH control of little value in purifying Lake Erie water. The pH value may vary widely without affecting physical properties of precipitated alumina, such as, ability to flocculate and settle, and effect in clogging filters; rate of precipitation more directly related to quantity of alum applied than to H-ion concentration of water under treatment. Increase in pH above isoelectric point gave increasing quantities of residual alumina as indicated by haematoxylin test, although complete precipitation was not obtained at values below 7. The haematoxylon test for alumina was observed to be more delicate in lake water at pH 8.1, than in distilled water at pH 6.1; 0.002 p.p.m. being detected in the former, and 0.1 in the latter. Residual alumina, reactive to haematoxylin and alizarin S, is present in filtered water from Division Ave. Plant in quantities of 0.1–0.4 p.p.m. **A Comparison between Hardness as Determined by Incrustants plus Alkalinity and Hardness Computed from Calcium and Magnesium Determined Volumetrically.** C. P. Hoover. 130–1. Total hardness of 756 samples of water, determined as incrustants plus alkalinity, compared as follows with results obtained by calculation from calcium and magnesium content, as determined volumetrically:

	RIVER WATER	FILTERED WATER
Incrustants plus alkalinity	254	96
Calculated	257	97

The method is accurate for routine purposes provided that, (1) 50 per cent excess of soda reagent is used, and (2) softened water does not contain excess lime or soda-ash. **Graphic Scheme for Expressing Results of Water Analyses.** C. P. Hoover. 132. Graphic scheme of W. D. Collins, for expressing results of water analyses, described. Quantity of each radical, as shown in analysis, is divided by its respective equivalent combining weight, and figures thus ob-

tained, plotted, anions against cations. **Carbon Dioxide Treatment of Lime Softened Water at Defiance, Ohio.** H. T. CAMPION. 133–5. Carbonation process in use at Defiance is described. After 15 months' operation, sand appears to be unchanged as regards deposits; effective size has increased, from 0.43 to 0.48 mm., and uniformity coefficient decreased, from 1.50 to 1.27. Practice has been to keep free carbon dioxide at 3 p.p.m., or slightly above neutrality to phenolphthalein. When this figure exceeded, increase in methyl orange alkalinity occurs. Quantity of coke burned, per million gallons water treated, during 1922, averaged 170 pounds, which is abnormally high. **Experience with Double Coagulation at Portsmouth, Ohio.** F. E. SHEEHAN. 136–8. Advantages of double coagulation, as evidenced at Portsmouth, are: less coagulant required, to obtain equal or higher degree of physical and bacteriological purification; character of floc improved; wash water required almost 50 per cent less; and operation of plant facilitated. Average turbidity in influent to filters averages less than 35, and B. coli less than 100 per 100 cc. An effluent of satisfactory quality prior to chlorination is readily obtained under these conditions. **A Comparison of the Performances of Individual Filters at the Lima Water Purification Plant.** E. E. SMITH, 2ND. 139–40. Details on filters at Lima are given. Study of figures recorded shows that filters with finer sand (0.37, compared with 0.43 mm.) require one-half minute longer to pass same quantity of wash water; have consistently higher loss-of-head; have shorter periods of service (about 20 per cent less); and require higher percentage of wash water. **A Comparison of the Four Principal Methods of Water Purification Control.** J. SHELDON SCOTT. 141–4. An investigation of relative values of principal means of bacteriological control—20° and 37° counts; presumptive and confirmed B. coli indices—was carried out over test period of 8 months, at Steubenville plant. Results are expressed graphically. Standard methods were employed, except that eosine—methylene blue agar was substituted for Endo's medium, for following reasons; uniformity, superior keeping qualities, and ease and accuracy of differentiation of colonies. In every case, point of lowest efficiency in count curve is point of highest efficiency in B. coli curve; indicating that removal of B. coli in the filter remains unaffected by conditions which result in low efficiencies, as measured by bacterial counts. Results are summarized as follows: (1) For control purposes, 20° counts are preferable to 37°. (2) Little choice between bacterial counts and B. coli tests for control of sedimentation and coagulation. (3) Bacterial counts preferable to B. coli tests for control of filtration. (4) Efficiencies as calculated from presumptive and confirmed B. coli indices respectively, are almost identical. **Phenol Tests by the Folin-Denis Reagent on Raw and Treated Mahoning River Water at the Youngstown Filtration Plant.** W. I. VAN ARNUM. 145–6. Phenol tests on raw and treated Mahoning River water with Folin-Denis reagent are tabulated. It was found desirable to make three 100 cc. distillations from each 500 cc. sample, owing to more intense color produced in first distillate. True phenol solutions showed no such concentration; indicating that part of coloration is due to substances other than phenol; possibly to hydrogen sulfide, which produces a marked coloration with the reagent, and is always present in the slag with which river is contaminated. Following conclusions are drawn from the investigation: (1) Decided diminution in phenol test

color developing in water after excess lime treatment. (2) Increase in phenol tastes and odors attends increased flow of slag in river. (3) Folin-Denis test is not specific for phenols. **Iron Romoval Practice in Ohio.** A. Elliot Kimberly. 147–51. There are 17 iron removal plants at present in operation in Ohio; principal ones being located at Garrettsville, Shelby, Lodi, Wadsworth, Xenia, Leroy and Barberton. Operation at these plants discussed and some results tabulated, which indicate that Darapsky's law, that the aerated water must be subjected to catalytic action of previously precipitated iron sludge, is correct, as applied to ground waters of Ohio; and, that roughing filters, and not coagulation basins, should precede finishing sand filters. Nozzles are preferred to aerators of splash type, as resulting aeration is more thorough, and removal of dissolved gases, more complete.—*R. E. Thompson.*

Water Treatment. Brunner Mond & Co., Ltd., Northwich (Eng.), 1923, 32 pp. Useful booklet, produced in exceptionally pleasing style, dealing with hardness; includes general discussion; descriptions of lime—soda ash and caustic soda—soda ash methods of softening; and methods of treatment of acid water and of water containing sodium bicarbonate, or oil. Medium hard water can be softened to 3 degrees hardness by lime—soda ash method at cost of 2–4 cents per 1000 gallons.—*R. E. Thompson.*

Tunnel for Water Mains under Cemeteries. G. H. Fenkell. Eng. News-Record, **90**: 1054, 1923. An 8.5 feet circular 4-ring brick tunnel 2200 feet long, carries 48 inch hammer-welded steel main under two cemeteries in Detroit, Mich. Depth at one end is 43 feet and at the other 57 feet. Pipe is laid on steel I-beams spaced on 5 feet centers. Single bump riveted joints used on circular seams. Manholes placed at 700 feet intervals.—*Frank Bachmann.*

Coal Consumption Records Used at Philadelphia Water-works. H. R. Cady. Eng. News-Record, **90**: 1054–5, 1923. The method of checking coal cunsumption in connection with traveling stokers consists of counter attached to driving shaft of each stoker, counter readings being multiplied by a factor to take into account travel of grate per revolution of shaft, width of stoker, weight of coal per cubic foot, and fire thickness. These factors are constant, except the last two, for any particular stoker; factor of weight per cubic foot varies with character of coal. Constant can be determined by weighing coal fed to stoker hopper, and reading counter and fire depth; or, by calculating volume of coal passing into furnace per turn of driving shaft, and determining weight of coal per cubic foot.—*Frank Bachmann.*

Sewage Effluent as Boiler Feed Water. Anon. Eng. News-Record **90**: 1049, 1923. If water soft, clarified effluent from septic tank may be used without treatment. Hard water effluent should be treated with lime and soda to soften, and remove organic matter.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Economics of Railway Water-Supply Systems Reviewed. C. H. Koyl. Eng. News-Record, **90**: 1091, 1923. Water softening on Great Northern

Railway estimated to save \$1000 per mile of road per year where there is an average of 10 trains per day. On El Paso & Southwestern Railway, this saving estimated at \$2700 per mile. Water-treating plants may repay more than their initial cost in a few weeks by release of engines and by increasing speed and service value of cars.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Water Supply and Irrigation Works, Wichita Falls, Tex. A. S. Fry. Eng. News-Record, **90**: 1080–1, 1923. Large hydraulic-fill storage dam, smaller diversion dam 15 miles downstream, and system of main and lateral canals are under construction to furnish water supply for Wichita Falls and to irrigate 110,000 acres. Cost of project estimated at \$4,500,000.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Second Water Purification Plant for Dallas, Texas. David Morley, Jr. Eng. News-Record, **90**: 1042–4, 1923. City has three sources of supply: artesian wells, Trinity river, which is filtered, and White Rock reservoir, which is filtered in new plant. New purification plant is designed for 15 m.g.d. Consists of low-lift pumping station, aerator, mixing channel, two sedimentation basins, secondary coagulant basin, 12 rapid sand filters, filtered-water reservoir, and wash tank. Aerator is of concrete, 90 feet long, 14 feet wide and 7 feet deep. Water falls over 8 steps, 86 feet long, so arranged as to give cascading effect, which removes tastes and odors. $CuSO_4$ is used at times in reservoir to destroy algae. From aerators, water passes through 700 feet of mixing channels; is settled in 2 basins, each 300 feet long by 75 feet wide and 16 feet deep; then to secondary basin, 74.5 feet long by 24 feet wide and 13 feet deep; and finally to filters. Lime and $FeSO_2$ are used as primary coagulants, and alum in secondary settling basin. Filters are designed for 2 gallons per square foot of filter area per minute. Plant costs \$420,000.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Underground Contamination of the Bad Axe, Mich., Water Supply. W. C. Hirn. Eng. News-Record, **91**: 138–9, 1923. Pollution entered through unused well, 430 feet from used well, through fissures opened by dynamiting, several years ago. Epidemic of intestinal disorders developed, which affected 75 per cent of 2200 population.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Experiments in Water Coagulation with Aluminum Sulphate. F. E. Daniels. Eng. News-Record, **91**: 93, 1923. With $Al_2(SO_4)_3$ and Na_2CO_3, maximum precipitation occurred between H-ion concentration limits of pH 6.0 and pH 7.0. In solutions more alkaline than pH 6.8, dissolution of $Al(OH)_3$ began, and continued with increasing alkalinity, until entire floc was redissolved at pH 10.5. Ca aluminates are less soluble than Na aluminates; dissolution did not begin so soon with precipitation formed from $Ca(OH)_2$, as with that formed from Na_2CO_3.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

High Yield from Small Watershed with Large Water Area. F. I. Winslow. Eng. News-Record, **91**: 64, 1923. A larger yield than normal from watersheds in eastern New England is found at Framingham, in Farm Pond. Increased

yield is attributed to possible underground flow to pond from slightly higher watershed.—*Frank Bachmann.*

Comparison of Cost of Purchasing and Installing Meters and of Additional Water Supply—Parts I and II. NICHOLAS S. HILL, JR. Amer. City, **29**: 8–11, 1923; **29**: 158–161, 1923. Lucid and strong arguments presented for selling water by meter, as contrasted with other methods of charging. Accompanying tables give data as to extent of metering of cities and towns of 25,000 population and over; also reduction in consumption by use of meter. Effect of metering on capital expenditures, on public health and on general efficiency of operation are discussed. Underlying principles of water charges are set forth and analyzed.—*W. Donaldson.*

The Function of Alum in Water Purification. W. F. DONOHOE. Amer. City, **29**: 32–3, 1923. Brief popular statement.—*W. Donaldson.*

New York City Searches Diligently for Water Waste. WILLIAM W. BRUSH. Amer. City, **29**: 42–3, 1923. Describes personnel and methods employed by the Department in routine detection and stopping of underground leaks. In eleven years of such effort, since 1910, number of leaks located and repaired was 1523; total leakage stopped amounted to 111 m.g.d., while cost per million gallons saved varied from $1.15 to $3.83.—*W. Donaldson.*

The Waste of City Water by Defective Fixtures. ANON. Amer. City, **29**: 123, 1923. Bulletin of Philadelphia Housing Association states that two months' inspection of 2335 premises in midwinter showed 105 leaky fixtures, wasting 5.3 mg.d. Eight leaky fire plugs wasted 1.7 m.g.d.—*W. Donaldson.*

A Jet Booster for an Old Water Supply. J. E. TUPPER. Amer. City, **29**: 142, 1923. At Pomeroy, Wash., in order to augment discharge through existing 10 inch gravity line, from reservoir, a 2 inch jet device was installed, operating from auxilliary supply at higher elevation. Additional head of 22 feet was gained.—*W. Donaldson.*

Improvoments in the Water Supply of Woodstock, Ill. KENDALL AUSTIN. Amer. City, **29**: 163, 1923. Woodstock, with daily consumption 720,000 gallons, has replaced former supply works, consisting of 5 wells, 100 to 2000 feet deep, equipped with air-lift and plunger pumps, by two Layne and Bowler wells 196 feet deep, equipped with motor-driven centrifugal deep well pumps. Saving of $46,000 per annum in cost of pumping is claimed.—*W. Donaldson.*

Metropolitan Water Board (London, Eng.) 17th. Annual Report. Can. Engineer, **45**: 8, August 21, 1923. During year ending March 1922, Board supplied 91,119.9 million imperial gallons to consumers. Daily average consumption 247.72 million gallons: 36.27 gallons per capita. Latter figure shows average decrease of 3.88 gallons, compared with figures of preceding year. Total estimated population supplied by Board was 6,861,449, representing increase of 57,885 during year.—*N. J. Howard.*

Report of Committee on Water Works and Water Supply. GEO. W. FULLER, Chairman. Proc. Amer. Soc. Municipal Improvements, 1922 Convention: 261–263. Report records a few points of interest in water works construction and operation.—*John R. Baylis.*

The Cleveland Water Supply. A. V. RUGGLES. Proc. Amer. Soc. Municipal Improvements, 1922, Convention: 264–268. Briefly describes the Cleveland, Ohio, water supply.—*John R. Baylis.*

Water Supply of Cities: General and Fundamental Principles. DABNEY H. MAURY. Jour. Western Society of Engineers, 28: 4, 111, April, 1923. Denver, Norfolk, Tulsa and Army water supply problems discussed. $7,300,000 bond issue to improve Denver's piecemeal constructed system. First unit filter plant capacity 64,000,000 g.p.d. on rate 150,000,000 gallons per acre per day. Plant can be increased to 192,000,000 gallons per day. Lake Prince project to increase Norfolk supply. Comparison cast-iron, wood-stave and concrete pipe. Bond issue representing $90 per capita to give Tulsa suitable water supply. Spavinaw Creek, 60 miles away with dry weather flow 17,000,000 g.p.d. to supply city. Army waterworks cost $11 per capita compared with $55 cost in average city (1917). In United States and possessions with 4,000,000 troops and 2,000,000 civilians not one case of typhoid or other water-borne disease charged to impurity of supply. Organization and operation of Construction Division.—*A. W. Blohm.*

The Distribution and Therapeutics of Iodine. A. JUDSON QUIMBY. American Medicine, 18: 4, 223, April, 1923. Selection of water supplies with regard to iodine content, addition of iodine-bearing mineral waters to existing supplies suggested to compensate for deficiencies. Review of theories concerning physiological action of iodine.—*A. W. Blohm.*

Final Report of the Water Power Resources Committee. Board of Trade, London, England, 1921. Committee appointed 1918 to examine and report on water resources of United Kingdom, availability for industrial purposes, conservation and systematic utilization. Water commission recommended to compile records, allocate water resources, adjust conflicting interests, control uses, group watersheds, develop rivers, improve law relating to surface and underground waters. Maps, tabulations, estimated cost of development.—*A. W. Blohm.*

Some Hints on General Water Works Maintenance. Sequel to "A progressive Water Works and Its Methods" (This J., 10: 1145). Fire & Water Eng. (5) **A Brief Summary of the East Bay Water Co's. Plant, as of October, 1922.** P. E. MAGERSTADT. 73: 677, April 18, 1923. Company operates in territory about 35 miles long; averaging from 2½ to 5 miles wide. It serves cities of Oakland, Berkeley, Alameda, Richmond, Piedmont, Albany, Emeryville, El Cerrito, San Leandro, and Newark. Population served is approximately 350,000. Some idea of size and activities may be gained from following facts: employees number 505; motor vehicles maintained, 83; volume of water filtered

during past 12 months, 5.169 billion gallons; watershed land owned, 42,000 acres; storage reservoirs, 3; with total capacity of over 19 billion gallons; distribution reservoirs, 39; with total capacity of 286 million gallons; transmission mains, 91 miles; distribution mains, 1146 miles; active services, 86,477; services gained during last 12 months, 5726; meters in ground, 83,137; hydrants, 2844; average daily consumption during past 12 months, 23.1 million gallons; pumping plants, 3 steam driven and 27 electrically driven. (6) **Construction.** L. L. Farrell. **73**: 678, April 18, 1923. All orders and instructions pertaining to construction and maintenance are passed through official channels to Corporation Yard Office. Concrete meter boxes and covers are used; manufactured by local companies. 2- and 3-inch mains are generally of wrought iron; 4 to 12-inch, of cast-iron; 12-inch, and larger, of sheet iron, about 30 feet long. 2-inch cast-iron pipe has been used recently with gratifying results; it is less susceptible to chemical action of soil and cement joints may be used to eliminate electrolytic action; comes in 5 feet lengths; made by McWane Foundries. Smaller mains are laid from 18 inch to 2½ feet deep; larger, from 3 to to 6 feet deep. Cement now used almost exclusively as joint filler, both on sheet and on c.-i. pipe. Practically every main has insulated joint every 100 feet; cement used for c.-i., and, for sheet iron mains, special flanged unions with fiber gasket, fiber tube over body of bolt, and fiber washers under bolt head and under nut. Services are also insulated wherever possible, both at main and on house side of meter. Oxy-acetylene welded joints have been tried out on 12-, 16-, and 20-inch lines, carrying 200 pounds pressure; they are not only more substantial than either lead bands, or rivets, but also much more economical. Services, up to, and including, 2-inch, are connected to main with lead service connection. All service taps, up to, and including, 6-inch, are made with pressure on main. All gate valves, and practically all hydrants, are installed at street intersections. Use of tractors and plows for actual breaking up of semi-permanent pavement, and also for general trench work in almost any kind of soil, has proven a decided success.—*Geo. C. Bunker.*

Putting the Water Works on a Self-Sustaining Basis. V. Bernard Siems. Fire & Water Eng., **73**: 417, March 7, 1923. Taking Water Department of Greater Baltimore as example there are given salient features of plan for obtaining revenues to take care of operating and maintenance expenses, sinking funds, interest on various bond issues, and small surplus to be used for any necessary extensions; or, in other words, to render this utility self-supporting. —*Geo. C. Bunker.*

Tools That Make the Water Works Man's Job Easier. Alexander Milne. Fire & Water Eng., **73**: 455, March 14, 1923. Brief notes on following devices: wireless pipe locator; magnetic dipping needle; electric leak locator; electric thawing apparatus; pipe pushing jacks; tapping machines; portable meter tester; portable air compressor; and trenching machines.—*Geo. C. Bunker.*

How to Prevent Spontaneous Combustion in Coal Piles. O. P. Hood. Fire & Water Eng., **73**: 495, March 21, 1923. Practical suggestions for fire and water works departments. Illus.—*Geo. C. Bunker.*

Water Company Inaugurates Weekly Advertising Campaign. Fire & Water Eng., **73**: 501, March 21, 1923. Davenport, Iowa, Water Company is publishing series of 25 weekly advertisements in local dailies, in order to make their methods and practices known to public and to their consumers.—*Geo. C. Bunker.*

Fixing the Value of Fire Protection Service. Caleb Mills Saville. Fire & Water Eng., **73**: 535, March 28, 1923. Public Utilities Commisssion of Connecticut recently rendered decisions whereby Ansonia Water Co. and Bridgeport Hydraulic Co. are permitted to make charges for that portion of their capital invested in excess construction of plant necessitated by fire protection service. In case of former company, municipality was ordered to make annual payment of $10, per hydrant in service, and inch-foot charge of $0.009; in latter case, municipality was ordered to pay $150,000 per year to company for fire protection service, on basis of 1.2 cents per inch-foot of mains. In this State, annual reports must be submitted to Commission by municipalities owning or operating utilities for public service.—*Geo. C. Bunker.*

Rapid Filter with Automatic Wash Gear. F. Johnstone-Taylor (England). Fire & Water Eng., **73**: 589, April 4, 1923. Brief illustrated description of continuous washing, or drifting sand, filter. Operating head of about 30 feet is necessary; filtering rate of 140 gallons (British) per square foot of bed area per hour can be worked to.—*Geo. C. Bunker.*

Water Softening Can Be Accomplished at Small Cost. Charles P. Hoover. Fire & Water Eng., **73**: 623, April 11, 1923. Instructive paper, well illustrated by diagrams, on water softening processes, based upon operation of Columbus, Ohio, Plant. Tables showing cost of operating and maintaining Water Softening and Purification Plant for years 1909 to 1922, inclusive, and cost of chemicals, are given. Influence of temperature, time, mass action, and addition of alum are discussed. At Columbus Plant lime, soda-ash, and alum are all added at practically same point; all of alum is now added to raw water as it enters plant. Here and at new Newark, Ohio, plant, all of chemicals required to soften water are added to approximately 25 per cent of water, which is subsequently mixed with the 75 per cent undosed portion of supply. This overtreatment results in quick formation of large flocs and crystalline precipitates. Carbonation of water to prevent deposits of carbonates in distribution system, meters, and hot water systems is discussed. Experiments with phosphoric acid have been dropped. Principal conclusions are: (1) It is necessary to get precipitates into flocculent crystalline condition, so that they will settle out almost instantly. (2) It is necessary to provide settling basins only sufficiently large to retain sludge, say 5 hours, at Columbus; or, perhaps, a Dorr Thickener, from which sludge is removed continuously, would be sufficient. More definite data can be given on this process after results of operation of thickeners at Highland Park, Ill., and Newark, Ohio, are available. (3) After sludge has been separated from water, in order to produce stability, carbonation with CO_2 gas should follow; or, normal carbonates may be converted to bicarbonates by acid treatment.—*Geo. C. Bunker.*

How to Stop the Contractor from Wasting Water. WILLIAM LUSCOMBE. Fire & Water Eng., 73: 673, April 18, 1923. Percentage of water sold contractors, in Gary, Ind., during building season months, if figured at regular meter rates, ranges from 3 to 8 per cent of total. In great majority of cases, water is furnished on flat rate basis, and during warmer months, when construction work is carried on in general way throughout city, water wasted is relatively large, and, by investigation, is believed sometimes to exceed all legitimate uses many times. Each party is cautioned in friendly, but firm, way, against wasting water, and for third offense, supply is discontinued, and not turned on again until assurance is given that privilege will not be abused, and payment of $1.00 made. In cases of frequent and flagrant violations offender will be required to provide suitable place for meter, and water will be furnished only at regular meter rates. Meters are not generally installed on account of high cost due to local conditions.—*Geo. C. Bunker.*

How Much Does a Consumer Really Require? ABEL WOLMAN. Fire & Water Eng., 73: 815, May 9, 1923. In discussion on possibility of reducing per capita consumption of water in Baltimore, Md., without detriment to individual or public health, following differences in demands for water are brought out: *subsistence demand*—that required for proper functioning of human mechanism—is set at 1½ gallons per person per day; *sanitary demand*—that covering usage for bathing, washing of clothes, toilet equipment, and minor necessary household uses—varies between 10 and 20 gallons per person per day; sum of subsistence and sanitary demands ranges from 15 to 25 gallons per day; but, allowing for a factor of safety, *maximum rational water requirement* may be set at 30 gallons per person per day for domestic purposes; however, in the United States, in most instances consumption is above this latter figure, and usually above 50 gallons, which is designated as *maximum reasonable use.* Daily per capita consumption in London is less than 50 gallons and average for principal towns in Great Britain is 42 gallons, as compared with 142 gallons in Baltimore. Requirements of human mechanism for water for continuance of life and for proper environmental sanitation are relatively low. In only few instances, do such requirements control actual per capita consumption in a community. Beyond a consumption of 50 gallons per person per day, irrational use of water begins; in this region curtailment may be made without damage to health. Correlation of water and disease, in bulk of cases, lies in factor of quality, and not that of quantity, of water consumed.—*Geo. C. Bunker.*

Regulations Concerning Water for Drinking and Culinary Purposes on Vessels Navigating on the Great Lakes and Inland Waters. Dept. of Health, Canada. 6 pp., 1923. Regulations approved by Order in Council on 19th June 1923. Water furnished is required to contain not more than 2 B. coli group organisms per 100 cc., determined according to A. P. H. A. standard methods (Phelps' calculation). List of prescribed areas where water shall not be obtained overboard without knowledge and consent of the department, is included.—*R. E. Thompson.* (*Courtesy Chemical Abst.*)

Effect of Meters on Water Consumption. D. H. Maury. Western Soc. Engr.; Eng. Contrg., **59**: 1087, 1923. Table and diagram summarize data.—*Langdon Pearse.*

Construction and Operation of Warren, Ohio, Water Filtration Plant. S. N. Vance, P. J. O'Connor. Mun. Cty. Eng., **64**: 183–8, 1923. Rapid filter plant; cost $201,270.57; has capacity of 6 m.g.d.; divided into 6 units. Provision is made for dry feed of alum amd lime. Mahoning R. water is treated by 3½ hour coagulation. Laboratory is provided.—*Langdon Pearse.* (*Courtesty Chem. Abst.*)

Features of New Well Supply at Memphis, Tenn. J. R. McClintock. Mun. Cty. Eng., **64**: 47–51, 1923. Well water development to serve 175,000 people with 18 m.g.d. Water contains 110 p.p.m. free CO_2. Air lift pumping is used, air supply being metered. Coke aerator trays are supplied in series of 4 superimposed; followed by rapid sand filters.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

,Charleston (S. C.) Water Treatment Notes. J. E. Gibson. Pub. Works, **54**: 284–5, 1923. Use of hydrated lime and of caustic soda for softening filtered water (hardness 20 to 25 p.p.m.) is described, the soda treatment requiring about ¾ grain of 76 per cent caustic soda per gallon as against 1½ grain hydrated lime. Cost is increased $16.00 per day, for 6 million gallons—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Chlorine Production at Independence, Mo. A. H. Gallagher. Pub. Works, **54**: 336–7, 1923. An electrolytic cell produced Cl for a period of 222 days at 4.81 cents per pound for Cl, with current at 1.7 cents per kilowatt hour. Operation is said to be simple, result good.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

A $4,500,000 Texas Water Supply Project. R. A. Thompson. Eng. Contrg., **60**: 277–80, 1923; Pub. Works, **54**: 158, 1923. Hydraulic fill dam; 100 feet high, 7500 feet long; built for Wichita Falls. Spillways are of masonry.—*Langdon Pearse.*

Cost of Supplying Water at Columbus, Ohio. C. P. Hoover. 1922 Ann. Rept., Supt. W. W.; Eng. Contrg., **59**: 1064, 1923. Total cost was $120.70 per million gallon. Average selling price was $160 per million gallon.—*Langdon Pearse.*

Portland Cement Joints for Force Mains. William Wheeler. N. E. W. W. Assn., 1923; Eng. Contrg., **59**: 1047–9, 1923. Methods and costs are described with tests of leakage.—*Langdon Pearse.*

Pump House and Intake Pipe Line Connection. Contract Record; Eng. Contrg., **59**: 1038–40, 1923. Describes river intake for water supply at Three Rivers, Que., for new paper mill, 36 inch pipe was laid 650 feet from shore.—*Langdon Pearse.*

Cost of Construction of 48-inch Water Main at New Bedford, Mass. S. H. Taylor. Ann. Rept. Water Bd., 1922; Eng. Contrg., **59**: 1060, 1923. Cost with pipe at $46.50 per ton and specials at $130.00 per ton on 18,813 feet averaged $25.58 per foot laid; including $4.31 for labor.—*Langdon Pearse.*

An Improved Pitometer. F. W. Greve. Eng. Contrg., **59**: 1050–1, 1923. Sketch and table are given.—*Langdon Pearse.*

Some Costs of Lead Substitute in Pipe Joints. V. F. West. N. E. W. W. Assn., 1923; Eng. Co itrg., **59**: 1051–2, 1923. Comparative cost figures on lead and leadite—show saving from $0.60 on 6-inch to $1.58 on 16-inch.—*Langdon Pearse.*

Present Status of Sanitary Engineering, H. P. Eddy. Am. Soc. C. E., 1923; Eng. Contrg., **59**: 1053–8, 1923.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Water Consumption at New Bedford, Mass. Cost of Cleaning and Testing Meters. S. H. Taylor. Ann. Rept., 1922; Eng. Contrg., **59**: 1076, 1083, 1923. Consumption was 79 gallons per capita daily in 1922; of which, domestic 29, manufacturing 32, and leaks and unaccounted, 18 gallons. Cost of cleaning and testing meters is given for 6, 3, $\frac{3}{4}$, $\frac{5}{8}$ inch: being $2.35, $3.90, $2.35 and $2.41 respectively.—*Langdon Pearse.*

Cost of Installing and Changing Meters at Portland, Oregon. Rept. Dept. Pub. Utilities, 1921.; Eng. Contrg. **59**: 1083, 1923 Costs were: installing $4,707; changing $0.779; removing $0.589; repairing $2.022. Mostly $\frac{5}{8}$ inch. —*Langdon Pearse.*

Effect of Filtration on Typhoid Death Rate at Columbus, Ohio. C. P. Hoover. Ann. Rept. Supt. W. W., 1923; Eng. Contrg., **59**: 1058, 1923. Table shows typhoid fever death rate from 1901–1922. After filtration began, average for 8 years 1901–1908 was 54.5 per 100,000; for 14 years 1909–1922, 10.5; with 1.2, in 1922.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Cost of Pumping Water at Columbus, Ohio. C. P. Hoover. Ann. Rept. Supt. W. W., 1922; Eng. Contrg., **59**: 1070, 1923. Cost was $18.63 per million gallon.—*Langdon Pearse.*

Cost of Water Main Construction at Pasadena, Cal. S. B. Morris. 9th Ann. Rept. Water Dept.; Eng. Contrg., **59**: 1070, 1923. Cost is given, for years 1914 to 1922 inclusive, for 4 and 6 inch cast iron pipe laid.—*Langdon Pearse.*

Cost of Laying Water Mains at Columbus, Ohio. C. P. Hoover. Ann. Rept. Supt. W.W., 1922; Eng. Contrg., **59**: 1073, 1923. Cost is given for pipe 4- to 24-inch, showing labor and material.—*Langdon Pearse.*

Private Fire Protection Charges and Metering of Sprinkler System. John Simpson. Pub. Works, **54**: 163–5, 1923. Discusses underlying principles.—*Langdon Pearse.*

Groined Arches. P. O. MACQUEEN. Am. Soc. C. E.; Pub. Works, **54**: 158-9, 1923.—*Langdon Pearse.*

Gasoline Operated Auxiliary Pumps. S. L. FEAR. Can. Sect. Am. W. W. Assn., 1923; Eng. Contrg., **59**: 1062, 1923.—*Langdon Pearse.*

Progress on the Wanaque Project. Pub. Works, **54**: 149–153, 191–4, 1923. Complete description given of progress and construction methods on concrete dam and 25 miles of aqueduct including tunnels. Machine mucking is described as well as unusual features in sheet piling and dewatering.—*Langdon Pearse.*

Wear Tests of Concrete. D. A. ABRAMS, ET AL. Proc. Am. Soc. Testing Materials, 21, 1013–38, 1921. From Chem. Abst., **16**: 1645, May 20, 1922. Eleven investigations carried out at Structural Materials Research Laboratory over a period of 6 years are outlined. Factors which gave concrete of high strength also gave concrete of high resistance to wear; increasing quantity of mixing water beyond minimum required to produce plastic caused material increase in wear; curing under favorable conditions exerted a marked influence in reducing wear; wear reduced by longer mixing and by increase in age.—*R. E. Thompson.*

A Proposed Method of Estimating the Density and Strength of Concrete and of Proportioning the Materials by the Experimental and Analytical Consideration of the Voids in Mortar and Concrete. A. N. TALBOT, ET AL. Proc. Am. Soc. Testing Materials, 21, 940–75, 1921. From Chem. Abst., **16**: 1645, May 20,1922. Relation between voids and strength of concrete. Method outlined for estimating strength and density of concrete of different proportions by determining voids in mortar only. Applied to estimating proportions necessary for obtaining given strength and density. Two appendices give technique of mortar void test and bulk and weight measurement in field.—*R. E. Thompson.*

Relation between Molded and Core Concrete Specimens. H. S. MATTIMORE. Eng. News Rec., **88**: 73, 1922. From Chem. Abst., **16**: 1645, May 20, 1922. Studies to determine reasons for differences in laboratory and field compressive tests of concrete have resulted in considerable progress in rational design of concrete mixes. Cores cut from concrete in place have higher strength than molded specimens.—*R. E. Thompson.*

The Theory and Practice of Stone-Wood (Magnesia Cement or "Composition") Floorings. A. STETTBACHER. Schweiz. Chem. Ztg., 113-7 1921. From Chem. Abst., **16**: 1646, May 20, 1922.—*R. E. Thompson.*

Failure of a Mortared Smoke Stack. VN. Rev. Mat. constr. trav. pub., **147**: 225, 1921. From Chem. Abst., **16**: 1646, May 20, 1922. Failure of a 54-in. smoke stack which was found to be listing 50 cm. (at the top) in the direction from which heavy winds were always blowing is explained by combination of

sulfur from fuel with the lime of mortar to form gypsum, causing swelling on the side furthest from wind. An analysis of the mortar showed 1-1.5 per cent SO_3 in the half against the wind and 7-12 per cent in the opposite side.—*R. E. Thompson.*

Deterioration of a Gas Plant Chimney. ANON. Business gaz., **46**: 77-8, 1922. From Chem. Abst., **16**: 1654, May 20, 1922. An analysis of the mortar on the inside of the chimney showed that it had been decomposed by sulfuric acid (4.8 per cent present). The mortar was loose, soft and moist, all the carbon dioxide had been eliminated and of the matter insoluble in hydrochloric acid only the silicates remained, principally aluminum silicate. The use of fuels high in sulfur and the cooling of the waste gases below the condensation point of water vapor, resulting in the formation of sulfuric acid, is believed to be responsible.—*R. E. Thompson.*

Destructive Effect of Gas Liquor on Ferro-Concrete. B. HAAS. Chem. Ztg., **46**: 39, 1922. From Chem. Abst., **16**: 1655, May, 20, 1922. Destruction of concrete tanks containing gas liquor probably caused by corrosive action of ammonium salts in liquor on tree lime of concrete. Method of making concrete resistant to this action is described.—*R. E. Thompson.*

The Construction of a Storage Reservoir on the Site of Underground Workings. T. C. GREENFIELD. Surveyor, **63**: 1616, 7-10, Jan 6, 1923,. Construction of a 200 million gallon storage reservoir (Blaen-y-Cwm reservoir) on site of an old coal mine at Beaufort, Breconshire, Wales, described in detail. Construction commenced in the autumn of 1918 and practically all the work below the surface is now completed. Concrete foundations for a dam core wall were carried down to the "Farewell" rock, necessitating the excavation of trenches 60 to 70 feet deep in places. A special punning machine of very simple design operated by an 8 h. p. Petter oil engine was used in the work.—*Rudolph E. Thompson.* (*Courtesy I. W. M.*)

Separation of Bacteria by Filtration with Zsigmondy-Bachmann Membrane Filters. H. MEYERINGH. Z. Hyg. und Infekt-Krankh., **97**: 116-136. 1922. Chem. Zentr., **94**: II, 313, 1923. Jour. Soc. Chem. Ind., April 6, 1923. p. 289A. Zsigmondy-Bachmann filters (cf. G. P. 329, 060 and 329, 117; J., 1921, 203A), if suitably selected, rapidly yield a germ-free liquid, and, moreover, the ease with which the residues are removed from the filters renders them especially suitable for separating bacteria from such liquids as water and urine. Their low absorptive capacity renders them suitable for filtering colloidal solutions. A lower grade of porosity is necessary to prevent propagation of individual species of bacteria through the filters than for simple filtration. By employing filters of low porosity, propagation of bacteria through the filters is entirely prevented, and these can be used with safety for the rapid production of germ-free drinking water, (L. A. C.)—*A. M. Buswell.*

Process for Removing from Water Excess of Oxidising Agents Used in Sterilising the Water. Permutit A. G. G. P. 357, 893, 1. 11. 13.—Jour. Soc. Chem. Ind.,

42: 14, 289 A, 1923.—Excess of chlorine, hypochlorites, ozone, hydrogen peroxide, and substances such as perborates and percarbonates which yield hydrogen peroxide used in sterilising water, are removed from the water by filtering it through metal oxides which have a catalytic action on, but do not enter into chemical reaction with, the substances in solution. Nickelic, cobaltic, ferric, and cupric oxides, and lead monoxide, or mixtures of these with manganic oxide, are suitable for the purpose, and these are preferably precipitated on porous organic or inorganic material such as base exchanging silicates. (L. A. C.)—*A. M. Buswell.*

The Stream-Line Filter. Prof. J. W. Hinchley. Chem. & Ind., 42: 20, 489, May 18, 1923. A remarkable filter had been invented by Prof. Hele Shaw, F. R. S. whose work on stream-line motion of fluids is so well known, and whose ingenious clutch, steering gear, hydraulic transmission, pipe joints and taps have made his name familiar all over the world. The filter consists of several thousand similar sheets of paper or fabric impervious to the liquid to be treated, and pierced accurately with a large number of equidistant holes. The sheets are placed in a pack so that the holes coincide, and are secured between endplates. By means of channels formed in these endplates alternate rows of holes may be connected together as the inlet for the liquid to be filtered, whilst the other holes connect with other channels in a similar way, forming the exit for the filtrate. True filtration may take place between the sheets through the interspaces formed by the roughness of the paper or fabric. By squeezing the pack, the finest materials, bacteria, colloid particles, etc. may be retained by the filter, and on releasing the pressure it may be readily cleansed by driving a washing liquid in either direction. The formation of a hard cake is not allowed to take place, but the precipitate or residue is removed by allowing the contents of the inlet holes to discharge either intermittently or continuously through a suitable orifice. The filter possesses all the useful properties of a sand or porous pottery filter with the wonderful addition of a means of adjustment of porosity and of cleansing which puts it in a separate class.—*A. M. Buswell.*

Steel High Pressure Line Installed by the City of Ottawa, Ont. R. E. W. Hagarty. Contract Record, 37: 10–1, 1923. 51-inch high pressure main, ¾ mile long, recently completed in Ottawa. Riveted steel pipe chosen as most economical type of construction. After testing to 225 pounds cold water pressure, pipes immersed in coal tar bath (300°F.) for 5 minutes, wrapped with layer of jute hessian cloth, and again treated with tar.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Descriptions of Some Water Works Pumping Plants. P. L. Evans. Contract Record, 36: 1278–9, 1922. Recent installations of Rees Roturbo pumps at Windsor, Guelph, Stratford and Montreal described and illustrated. This type of pump is also being widely used for general industrial purposes, such as boiler feed, etc.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Water Supply of Montreal. Anon. Contract Record, **36:** 1269–71. 1922; **37:** 7–10, 1923. Review of development of water works system of Montreal. Supply drawn from St. Lawrence River through open aqueduct 40 miles in length.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Early Public Health in Toronto. Robert Wilson. Pub. Health Jour., **14:** 210–4, 1923. History of public health legislation in Toronto reviewed. Board of Health dates back to at least 1861 and first Medical Health Officer appointed in 1883. Sanitary conditions of City at that date contrasted with present pure water supply, absence of privy pits, incineration of garbage, etc. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Investigations in the Sanitation of Swimming Pools. A. V. Delaporte. Bull. **8:** Division of Sanitary Engineering, Provincial Bd. of Health, Ont.; 40th Annual Rept., 163–74, 1921. Investigation of 4 swimming pools in Ontario. Found that, if residual Cl in the pool water before bathing commenced in excess of 0.2 p.p.m., water would remain practically sterile throughout bathing period. Algal growths successfully treated by applying $CuSO_4$ after bathing over Saturday night, precipitated copper being removed by filtration before bathing commenced Monday. Analysis of water showed that no trace of Cu remained in solution.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Fortieth Annual Report. Provincial Bd. of Health, Ontario, Canada. 1921. 438 pp. In 1910 there were but 8 filtration plants and 1 chlorination plant in Ontario; while in 1921 42 per cent of public water supplies were protected by filtration and over 82 per cent by chlorination. Typhoid death rate of cities in the province reduced from 51.3 to 4.3 per 100,000 during the past 12 years. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Medical Health Officer's Report, 1922. Vancouver, B. C., Canada. F. T. Underhill. 31 pp. Water supply drawn from Capilano River and Seymour Creek. Av. compn., in p.p.m., of Capilano and Seymour waters, respectively, was as follows: total solids, 49.6, 48.3; residue on ignition, 31.6, 31.6; organic residue, 18.0, 16.7; chlorides, 2.77, 2.59; free NH_3, 0.014, 0.013; albuminoid NH_3, 0.028, 0.026; nitrates, 0.71, 0.67; nitrites, none, none; and reaction, neutral, neutral. Only 3 cases of typhoid reported and no fatalities from this disease occurred during year.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Typhoid Fever at Cochrane. J. W. S. McCullough. Pub. Health Jour., **14:** 220–2, 1923. Typhoid epidemic at Cochrane, Ont., believed to have been directly caused by pollution of water supply. Supply obtained from springs; Spring Lake, the overflow from the springs, being used as auxiliary supply. During dry season last fall and during the winter quantity of water derived from springs was inadequate, and considerable amount of water drawn from Lake level of which consequently lowered by nearly 6 feet. At time of outbreak level of water nearly 3 feet below that of lower lakes receiving town sewage, and, as result, sewage-contaminated water flowed back and entered intake. During this time blanket of snow and ice effectually concealed from view true

conditions. Chlorinating apparatus has been installed and in operation since that date.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Chemical Control on a Boiler Plant. W. Whitehead. Gas World, **76:** 1967 (Coking sex.), 13–4, 1922; Iron and Coal Trades Review. **104:** 457. From Chem. Abst., **16:** 1854, June 10, 1922. Combustion and flue gas control and water softening discussed.—*R. E. Thompson.*

Graphical Studies of Gas Producer Operation. W. Claus and L. Neussel. Ver. deut. Ing., **65:** 769–73, 1921. From Chem. Abst., **16:** 1856, June 10, 1922. Series of charts showing (a) chemical composition of producer gas, (b) temperature of combustion, and (c) most advantageous operation, were drawn, using as basis ternary diagram suggested by W. Ostwald in his book "Graphics of Combustion Engineering" (cf. C. A. **14:** 2414).—*R. E. Thompson.*

Graphical Treatment of Stack Gas Analysis and of Producer Gas Analysis. W. Trinks. Blast Furnace Steel Plant, **10:** 131–5, 1922. From Chem. Abst., **16:** 1856, June 10, 1922. Review of charts introduced by Ostwald and developed by Claus and Neussel (see preceding abstracts and C. A. **16:** 1144).—*R. E. Thompson.*

Steam Efficiencies. T. W. Harper. Gas World, **76:** 319–21, 1922. From Chem. Abst., **16:** 1857, June 10, 1922. Boilers and accessories, their merits and operation, feed water, scale, solvents, water softening, draft, grate area, superheaters and radiation losses discussed.—*R. E. Thompson.*

Iodine; Rapid Determination of, in Mineral Waters Containing Sulphides. J. Dubief. Ann. Falsif, **16:** 80–82. 1923. Chem. and Ind., **42:** 22, 471 A, June 1, 1923. Sulphides and organic matter are oxidised with alkaline potassium permanganate and halogens then liberated with sulphuric acid, and dissolved in carbon bisulphide. Excess of permanganate is removed with hydrogen peroxide. If weight of bromine present is less than 5 times that of iodine it does not interfere with colorimetric determination of iodine in carbon bisulphide solution, and this is immediately proceeded with. If more than this proportion of bromine is present, bromides of iodine are formed and colour of carbon bisulphide solution becomes yellowish. N/10 potassium thiocyanate solution is then added drop by drop, with agitation, until yellow colour disappears and solution becomes violet again. By this means 0.05 mgm. of potassium iodide can be detected mixed with 2000 times its weight of bromide. Solution should not contain more than 0.5 mgm. of iodine or coloration is too intense for exact determination. The iodine solution must be kept perfectly cool to avoid loss of iodine.—*A. M. Buswell.*

Determination of Carbonate Ion in Mineral Waters Containing Sulphides. F. Touplain and J. Dubief. Ann. Falsif., **16:** 76–80, 1923. Abstracted in Chem. & Ind. **42:** 22, **471 A**, June 1, 1923. Direct determination of carbonate ion in mineral waters by evaporation to dryness, liberation of carbon dioxide with sulphuric acid, and subsequent absorption with soda-lime, gives inac-

urate results in presence of sulphides owing to variation of the equilibrium between hydrogen sulphide and carbonic acid, oxidation of sulphur to strong acids, and production of sulphur dioxide, which is weighed as carbon dioxide. Sulphides may be eliminated by agitating the water with a small excess of lead peroxide for about 15 min. and subsequently adding hydrogen peroxide and warming to 45°C. for half an hour. Water is cooled, filtered, and carbon dioxide liberated with a mixture of sulphuric acid (2 vols.) and concentrated potassium bichromate (1 vol.) by which any thiosulphates not completely oxidised are transformed into sulphates and sulphuric acid. Carbon dioxide set free is then free from sulphur dioxide.—*A. M. Buswell.*

Standardization of Analytical Methods for Analysis of Potable Waters in the Belgian Army. Ch. Sillevaerts. Arch. Med. Belg., **75:** 753, 1922; Wasser und Abwasser **18:** 17. January 13, 1923. Methods for the usual chemical determination. Methods for bacteriological work include counts on meat extract peptone-gelatine; Bact. coli determinations using Vincent's phenol broth at 41°C; the cholera red test in peptone water. Waters are to be grouped into 3 classifications: (1) good; (2) usable after treatment; (3) bad.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Safe Water for Camping Parties. "Radio Health Hints," N. Y. State Bd. Health, Public Health (Michigan), **11:** 240, 1923. If possible, carry supply of water from home. Look over source of water supply. Suspicious water should be boiled 5 minutes before use. One well in New York State caused 60 cases of typhoid last year.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Influence of Silt in the Velocity of Water Flowing in Open Channels. A. B. Buckley, Jr. Water and Water Eng., **25:** 132, April 20, 1923. Discharge of Nile, obtained by Buckley-Wilson discharge recorder, operated by float stations 5 km. apart and automatically combining surface slope and depth according to Kutter's formula, was too low at times of arrival of silt-containing waters. Error of Kutter's, Bazin's, and Manning's formulae as much as 50 per cent. Introduces a new formula (not stated in article) known as Beleida formula which is said to give very accurate results at such times by introduction of a silt factor. Work on the Nile should be correlated with work done elsewhere.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Calcutta Water Supply. Anon. Water and Water Eng., **25:** 140, April 20, 1923. Taken from the River Hooghly and supplied both filtered and unfiltered. Filtered water is taken 12 miles above city and passes through slow sand filters. Capacity of filters will be increased from 35 to 70 m.g.d. (Imperial) and an 8 m.g. service reservoir will be constructed at Tallah.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Durban (So. Africa) Water Supply. Anon. Water and Water Eng., **25:** 141, April 20, 1923. Great difficulty with silt has been experienced. The Camperdown reservoir has lost 12,272,000 Imp. gallons capacity since September, 1920. At Umlas works there are 8 slow sand filters cleaned on an average

of once a month. Coedmore works has 6 slow sand filters cleaned on an average of 14 times a year. Six new beds similar to the existing beds, but much larger, are being constructed with total area of 66,378 square feet. Clear water reservoir with earth wall and puddle core has a capacity of 105 m.g. (Imp.). Additional pipe lines are being laid to increase discharge capacity to minimum of 6 m.g.d. Only plant in South Africa to use liquid chlorine. This has given satisfaction.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Apparatus for Chlorinating Water or Other Liquid. W. Patterson. British Patent, 188045; Water and Water Eng., **25**: 147, April 20, 1923. Relates to apparatus of the type in which chlorine flow is measured or calculated by taking difference in pressure on each side of a restricted opening through which the gas passes before admixture with the liquid to be chlorinated. It is therefore to be distinguished from Brit. Pats. 158578 and 166191 in which the flow of chlorine is actually measured by the sealing device itself. The object is to provide isolation of the chlorine-control apparatus from the water or liquid to be chlorinated.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst*).

Waterway Building and Swimming Pools. Max P. Grempe. Deutsche Tiefbau-Zeitung, **22**: 258, 1922; Wasser und Abwasser, **18**: 60, February 10, 1923. When streams are being canalized, swimming pools may be constructed behind the retaining walls and fed by, and emptied into, stream. They do not interfere with shipping as they are not in canalized section. Where pure condenser water available it may be utilized for such heat as it contains.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Contamination of the Sub-Soil as a Result of a Fire. M. Levy. Ann. Hyg. Publ. et Med. Legale, **38**: 284, 1922; Wasser und Abwasser, **18**: 66, March 10, 1923. In June 1917, factory at Grafenstaden, in Alsace-Loraine, burned, and water was pumped into the fire for 24 hours, from the Ill river. Water of shallow wells near by became turbid and had a petroleum taste. The chlorides, oxygen consumed, bacterial count, and Bact. coli content were all raised. After six weeks contamination had subsided.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

St. Louis Tests Three Water-Main Joint Materials. Leland Chivvis. Eng. News-Record, **91**: 190–1, 1923. Tests were made with lead, cement and leadite. Conclusions reached were: Cement and leadite far superior to lead as insulators. Insulating value of these materials not vitiated by water in pipe. Cement and leadite will stand far more deflection than lead, without serious leakage. Lead and leadite joints can be made in any season and under adverse conditions; while cement is under a disadvantage in winter and in wet trenches. Lead and leadite joints permit water to be turned on and line put in service immediately; while cement requires period of preliminary setting. Cement joints are hard to gouge out. Sulphur fumes of leadite might become oppressive in confined working space. St. Louis is planning on laying considerable amount of small pipe with cement joints, and, unless price of lead drops, will try leadite during freezing weather.—*Frank Bachmann.*

NEW BOOKS

Report of the Committee on Sedimentation. THOMAS WAYLAND VAUGHAN, Chairman. Presented at annual meeting of Division of Geology and Geography of National Research Council, April 18, 1923. Issued by National Research Council. Price $1.00. 68 pages mimeographed. Report contains following articles: **Studies in Sedimentation in the University and Colleges in the Eastern Part of the United States.** J. VOLNEY LEWIS. **Studies in Sedimentation in the University and Colleges between the Allegheny Front and the Rocky Mountains.** A. C. TROWBRIDGE. **Studies in Sedimentation by the State Geological Surveys.** J. A. UDDEN. **Investigations of Sediments by Federal Institutions and the Carnegie Institution of Washington.** THOMAS WAYLAND VAUGHAN. **Chemical and Physical Researches on Sediments.** H. E. MERWIN. **Color Blocks for the Description of Sediments.** M. I. GOLDMAN. **Treatise on Sedimentation.** W. H. TWENHOFEL. **Discussions at the Meeting of the Committee Held in Ann Arbor, Mich., December 27, 1923. Abstract of Sven Oden's Work on the Determination of the Effective Radius of Particles by Their Rate of Fall through a Fluid.** THOMAS WAYLAND VAUGHAN. **Flocculation of Colloids.** R. C. WELLS. **The Stratified Subsidence of Fine Particles.** C. E. MENDENHALL AND MAX MASON. **Notes and Comments Relating to Sediments and Sedimentation,** W. H. TWENHOFEL. **Discussion.** A. C. TROWBRIDGE. **Discussion.** MAX LITTLEFIELD. **Seasonal Deposition in Marine Waters.** R. W. SAYLES. **Discussion.** C. E. VAN ORSTRAND. **Remarks on the Study of Sedimentation by Artificial Precipitation.** HENRY S. WASHINGTON. A further abstract seems impractical. The abstractor believes however, that the article on Sven Oden's work on the determination of the effective radius, etc., by T. W. Vaughan and the article on "Flocculation of colloids" by R.C. Wells will be of special interest to water works people. The rest of the report is of more interest to geologists and geographists.—*A. M. Buswell.*

Surface Tension and Surface Energy and Their Influence on Chemical Phenomena. R. S. WILLOWS AND E. HATSCHEK. Third edition, pp. 136. London, J. and A. Churchill, 1923. Price 6s. 6d. Chem. & Ind., 42: 19, 477, 11 May, 1923. This edition prepared by Dr. Willows, is nearly twice the size of the first edition which appeared in 1915, and has been brought carefully up to date. The chief enlargements comprise an account of the important recent work of such investigators as Langmuir and Hardy on the properties of thin films, polarised molecules and lubrication. A clear and reasoned account is given of the main aspects of the subject, and its brief treatment is quite comprehensive. The book can be heartily recommended to those who wish to become acquainted with the essentials in this rapidly widening field, which interests biologists, physicists and chemists alike. (*J. W. McBain.*)—*A. M. Buswell.*

The Corrosion of Metals and Its Prevention. NATHAN VAN PATTEN. Annotated and carefully indexed bibliography, containing over two thousand references to literature of corrosion. Covers to January, 1923. Scope includes theory, for both ferrous and non-ferrous metals; electrolysis; and methods of combating. Invaluable aid to corrosion research. Typography, paper, and

binding leave nothing to be desired. Author was formerly Assistant Librarian Massachusetts Institute of Technology; is now Librarian of Queen's University, Kingston, Ontario, Canada. Limited edition. 180 pp.; cloth; $5.00. Apply to author. (Chance of unusual kind; merits close consideration of those concerned. ABSTR.)—*Frank Hannan.*

Bergey's Manual of Determinative Bacteriology. A Key for the Identification of Organisms of the Class Schizomycetes. By the Committee on Determinative Bacteriology, of the Society of American Bacteriologists, under the Chairmanship of David H. Bergey, Laboratory of Hygiene, University of Pennslyvania. Baltimore, Williams and Wilkins Company, 1923, pp. 442. Price $5.50. Much confusion has existed in the classification of the bacteria and perhaps no other group of living things have received worse treatment with respect to proper nomenclature. Early works on the classification of bacteria sought to distinguish them entirely on the basis of morphology. Later work however has shown this to be hardly possible. Wide differences have been shown in the physiological activity of morphologically similar organisms. It has, therefore, been necessary to recognize species by their physiological characteristics. This lead to several new attempts at systematic classifications. Much of this work was shown to be faulty by Buchanan who proposed a classification which conforms strictly to the Botanical Code of nomenclature. Bergey's Manual has encorporated much of Buchanan's classification of genera and has added descriptions of species with useful keys to aid in the identification of organisms. The Committee has brought together in this book information which heretofore it has been necessary to seek in a large number of original sources. It is the only work of this kind since the publication of the "Determinative Bacteriology," by Chester. The latter book is now far out of date.

In the new work the Genus Bacterium has been omitted entirely and in its place a number of other genera have been substituted. The colon group is included in the Genus Escherichia. What was formerly known as Bacterium coli now becomes Escherichia coli. Bacterium aerogenes is now Aerobacter aerogenes. The Genus Bacillus has been reserved for spore-bearing aerobes. New genera have been created for the non-spore-bearing organisms which were formerly included in this genus. For example, the etiological agent in typhoid fever is now designated as Eberthella typhi. It will be some time before the majority of bacteriological workers become familiar with the new nomenclature, but Bergey's Manual will doubtless be a great aid in bringing this about.—*R. C. Salter.*